THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Making Mobility-as-a-Service

Towards Governance Principles and Pathways

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Abstract

Mobility-as-a-Service (MaaS) is a service concept that integrates public transport with other mobility services, such as car sharing, ride sourcing, and bicycle sharing. The core idea is that intermediary digital services make it easier for users to plan, book, and pay for complementary mobility services, thereby facilitating less car-centric lifestyles. However, although MaaS has gained much interest in recent years, the concept has proven difficult to realize. Accordingly, there is a prevalent demand for knowledge on how to enable and push MaaS developments.

Conceptualizing MaaS developments as an innovation process that might contribute to a sustainability transition, this thesis sets out to improve the understanding of how public sector actors can facilitate action in the early phases and steer the innovation trajectory towards addressing long-term sustainability goals. The public transport authority in Västra Götaland (Sweden), and its attempts to facilitate MaaS developments, is used as a starting point. Three of its MaaS-related activities between 2016 and 2019 are analyzed based on participatory observation and stakeholder interviews. Additionally, the thesis draws on two qualitative studies of MaaS developments situated in Finland and Australia.

The thesis' contribution to the research field of MaaS is threefold. Firstly, it explores expectations of MaaS. A majority of the actors involved in the studied MaaS developments reckoned that MaaS will support a modal shift away from private car use. Still, while some actors were confident that this will lower the negative externalities of personal mobility systems, others feared that it will reinforce social and environmental problems. Of note is that none of these views are yet backed by any extensive empirical evidence, the shortage of which is an ongoing challenge for MaaS developments. Secondly, the thesis identifies institutional factors that shape MaaS developments. The studied developments were enabled by novel information technologies and motivated by the need to lessen the negative impacts of private cars. Yet, the developments brought together actors that had not previously collaborated and challenged models of collaboration, business, and customer relations, which made them contingent on complex modifications within and beyond personal mobility systems. Thirdly, the thesis examines how the public sector governs MaaS developments. The governance approaches varied across Sweden, Finland, and Australia in terms of leading actors, methods of intervention, and underlying motivations, but were yet to deliver much tangible results for citizens in all three countries.

Based on these findings, the thesis proposes principles and pathways for MaaS governance. The principles advocate a broad set of activities to address all the institutional factors that impede MaaS developments. In contrast to the observed governance approaches, this includes activities aimed at strengthening mobility services and active mobility, and at weakening the private car regime. The pathways describe four roles public sector actors can take in MaaS developments – MaaS Promoter, MaaS Partner, MaaS Enabler, and Laissez-Faire – and illustrate how the method(s) of intervention can be adjusted between innovation phases. The principles and pathways thereby provide a comprehensive tool for understanding and enhancing public-private dynamics in MaaS developments.

Keywords: Mobility-as-a-Service; Sustainability transitions; Collaborative innovation

Acknowledgements

Although only my name appears on the front cover, this thesis is a product of collaboration. I have been fortunate to be surrounded by a diverse, knowledgeable, and supportive community throughout my doctoral project. Accordingly, I am thankful to many people.

First and foremost, my research is primarily based on interviews and observations. I have many times been worried that MaaS users, public transport planners, car sharing managers, or start-up CEOs would not be willing to talk to me. This has repeatedly proven not to be the case. A lot of people have generously invited me to their offices and homes and devoted their valuable time to me. For this, I am tremendously grateful.

I am also grateful to my colleagues at the division Design and Human Factors at Chalmers University of Technology. My principal supervisor MariAnne Karlsson offered a much-needed steady hand during a rewarding but demanding doctoral project and pushed me to develop as a researcher. Likewise, my co-supervisor Jana Sochor kindly shared her vast knowledge about MaaS and challenged me to up the quality of my publications by sharp-sightedly identifying logical errors and contradictions. Together with Jonas Tuveson, Anneli Selvefors, and Sara Renström, I had the opportunity to teach tomorrow's design engineers about the relationships between how products and services are designed and how they contribute to sustainable development (or not). I believe that I learned as much as the students. I shared an office with Eva Simonsen and Fjolle Novakazi: two cheerful, smart, and impressive persons. Together with the rest of the Design and Human Factor staff, they made it fun to come to work. The *skitgubbe* tournament, the *fika* conversations, and the *Tabata* workouts provided vital breaks from the gravity of the doctoral endeavour.

Region Västra Götaland is a truly inspiring workplace, which has given me practical experience of working with public transport improvement. Without Ulrika Bokeberg, my manager at the division of Public Transport and Infrastructure, this doctoral project would not have been possible. Her trust in me allowed me to balance the (sometimes overwhelming) demands from academia with my role as a public servant. One day I hope to be as enthusiastic and knowledgeable as she is. I have also worked closely with Line Rondestvedt de Verdier, Sara Persson, and Leif Magnusson on Region Västra Götaland's program for sustainable transport-related research and development. This work deepened my understanding of the complexity of innovation projects. Suzanne Frej Pedersen, Calle Blomberg, and Baskim Zeciri were patient with me, even though I have not yet learned how to use our case management system, have frequented conferences that do not accept invoice payments, and have never filled in my time sheets in time. The rest of the Public Transport and Infrastructure team all contributed to a welcoming and positive atmosphere that I truly appreciate. I am moreover thankful for the positive feedback from the Public Transport Committee.

I have collaborated closely with Västtrafik throughout my doctoral project. This partnership has been a cornerstone in my research design and provided me with hands-on experience of MaaS developments. I am therefore indebted to a lot of people at Västrafik but especially to the project managers for Västtrafik's MaaS work, Elisabeth Elm and Marita Albrektson, who made me feel like a proper member of the MaaS team.

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One of my empirical studies is situated in New South Wales, Australia. My undertaking of that study was enabled by two research visits to ITLS – the Institute of Transport and Logistics Studies at the Business School of University of Sydney. David Hensher organized these visits. He also gave me the opportunity to act as workshop chair at the 16th International Conference on Competition and Ownership in Land Passenger Transport. I am thankful for this and inspired by David's expertise, curiosity, and ability to get things done. At ITLS, I have also co-authored a book on MaaS together with David as well as Chinh Ho, John Nelson, Corinne Mulley, and Yale Wong. Overall, ITLS provided another context packed with friendly and knowledgeable people who helped me broaden my understanding of transport-related research and issues.

Acting on behalf of the Swedish Ministry of Enterprise and Innovation, the collaboration group for the Next Generation's Travel and Transport commissioned me to draft a roadmap for MaaS developments in Sweden together with Per-Erik Holmberg, Anna Kramers, Adam Laurell, and Anna Pernestål Brenden. I am thankful for this opportunity to (try to) translate research findings into policy. It deepened my understanding of how difficult collaborative innovation and sustainability transitions are to manage and influence in practice. Per-Erik Holmberg and Adam Laurell have moreover been helpful in many different capacities throughout my research.

The first draft of this doctoral thesis was quite terrible. Along with my supervisors, several people have helped me transform it into something that is more comprehensive and readable. A large contribution came from Steven Sarasini. He did an outstanding job as discussant during my mock defense and gave me feedback that helped me improve my use of theory, my lines of reasoning, and my writing.

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Appended Papers

Paper A – Smith, G., Sochor, J., & Karlsson, I. C. M. (2018). Mobility as a Service: Development scenarios and implications for public transport. *Research in Transportation Economics*, 69, 592-599. doi:10.1016/j.retrec.2018.04.001

Smith planned the study, collected the data, performed the analysis, and wrote the paper with support and feedback from Sochor and Karlsson.

Paper B – Smith, G., Sochor, J., & Karlsson, I. C. M. (2019). Public-private innovation: Barriers in the case of Mobility as a Service in West Sweden. *Public Management Review*, 21(1), 116-137. doi:10.1080/14719037.2018.1462399

Smith planned the study, collected the data, performed the analysis, and wrote the paper with support and feedback from Sochor and Karlsson.

Paper C – Smith, G., Sochor, J., & Sarasini, S. (2018). Mobility as a service: Comparing developments in Sweden and Finland. *Research in Transportation Business & Management*, 27, 36-45. doi:10.1016/j.rtbm.2018.09.004

Smith planned the study and collected the data with Mukhtar-Landgren. Smith performed the analysis. Smith and Sarasini wrote the paper with support and feedback from Sochor.

Paper D – Mukhtar-Landgren, D., & Smith, G. (2019). Perceived action spaces for public actors in the development of Mobility as a Service. *European Transport Research Review*, 11(1), 32. doi:10.1186/s12544-019-0363-7

Smith and Muktar-Landgren planned the study, collected the data, performed the analysis, and wrote the paper together.

Paper E – Smith, G., Sochor, J., & Karlsson, I. C. M. (2020). Intermediary MaaS Integrators: A case study on hopes and fears. *Transportation Research Part A: Policy and Practice*, 131, 163-177. doi:10.1016/j.tra.2019.09.024

Smith planned the study, collected the data, performed the analysis, and wrote the paper with support and feedback from Sochor and Karlsson.

Paper F – Smith, G., & Hensher, D. A. (2020). Towards a framework for Mobility-as-a-Service policies. *Transport Policy*, 89, 54-65. doi:10.1016/j.tranpol.2020.02.004

Smith planned the study, collected the data, performed the analysis, and wrote the paper with support and feedback from Hensher.

Paper G – Smith, G., Sochor, J., & Karlsson, I. C. M. (2019). Adopting Mobility-as-a-Service: An empirical analysis of end-users' experiences. *ICoMaaS 2019 proceedings*, 86-98.

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Additional Publications

On Mobility-as-a-Service

Hensher, D. A., Ho, C. Q., Mulley, C., Nelson, J. D., Smith, G., & Wong, Y. Z. (2020). *Understanding Mobility as a Service (MaaS): Past, Present and Future*. Elsevier.

Isaksson, K., Oldbury, K., Hedegaard Sørensen, C., Paulsson, A., Smith, G., & Rignell, M. (2019). Problembilder som formar framtidens mobilitet: exemplet ”mobilitet som tjänst” i kollektivtrafikplanering. In J. Syssner (Ed.), *Ett nytt kontrakt för samhällsbyggande* (pp. 177-200). Boxholm: Linnefors förlag.

Karlsson, I. C. M., Mukhtar-Landgren, D., Lund, E., Sarasini, S., Smith, G., Sochor, J., & Wendle, B. (2017). *Mobility-as-a-Service: A tentative framework for analysing institutional conditions*. Paper presented at the 45th European transport conference, 4-6 October, Barcelona.

Karlsson, I. C. M., Mukhtar-Landgren, D., Smith, G., Koglin, T., Kronsell, A., Lund, E., Sarasini, S., Sochor, J. (2020). Development and implementation of Mobility-as-a-Service: A qualitative study of barriers and enabling factors. *Transportation Research Part A: Policy and Practice*, 131, 283-295. doi:10.1016/j.tra.2019.09.028

Smith, G. (2020). Mobility-as-a-Service and Public Transport. In C. Mulley, J. D. Nelson, & S. Ison (Eds.), *The Routledge Handobook for Public Transport*. Taylor and Francis.

Smith, G., Sarasini, S., Karlsson, I. C. M., Mukhtar-Landgren, D., & Sochor, J. (2019). Governing Mobility as a Service: Insights from Sweden and Finland. In M. Finger & M. Audouin (Eds.), *The Governance of Smart Transportation Systems: Towards new organizational structures for the development of integrated, electric, automated and shared mobility*. Springer International Publishing. doi:10.1007/978-3-319-96526-0_9

Smith, G., Sochor, J., & Karlsson, I. C. M. (2017). P*rocuring Mobility as a Service: Exploring dialogues with potential bidders in West Sweden*. Paper presented at the 24th World Congress on Intelligent Transportation Systems, 29 October – 2 November, Montreal.

On Open Data and Collaborative Innovation

Smith, G. (2018). Public Sector Open Innovation: *Exploring Barriers and How Intermediaries Can Mitigate Them* (licentiate thesis). Gothenburg: Chalmers University of Technology.

Smith, G., & Akram, A. (2017). *Outbound open innovation in the public sector: The roles of intermediaries*. Paper presented at the 4th World Open Innovation Conference, 14-15 December, San Francisco.

Smith, G., Burden, H., & Hjalmarsson, A. (2016). *ElectriCity Innovation Challenge 2015: Experiences*. Paper presented at the 29th International Electric Vehicle Symposium 2016, 19-22 June, Montreal.

Smith, G., Hjalmarsson, A., & Burden, H. (2016). *Catalyzing Knowledge Transfer in Innovation Ecosystems through Contests*. Paper presented at the 22nd Americas Conference on Information Systems, 11-14 August, San Diego.

Smith, G., Ofe, H. A., & Sandberg, J. (2016). Digital Service Innovation from Open Data: Exploring the Value Proposition of an Open Data Marketplace. *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 1277-1286. doi:10.1109/HICSS.2016.162

Smith, G., & Sandberg, J. (2018). Barriers to innovating with open government data: Exploring experiences across service phases and user types. *Information Polity*, 23(3), 249-265. doi:10.3233/IP-170045

On Transport, Governance, and Research

Smith, G. (2017) Ethical Risks of Pursuing Participatory Research as an Industrial Doctoral Student. *Proceedings*, 1, 167. doi:10.3390/IS4SI-2017-04013

Smith, G., Strömberg, H., & Wallgren, P. (2017). Electric Bicycle Adoption: Opportunities and Requirements. In P. Wallgren (Ed.), *System Perspectives on Electromobility* (2 ed., pp. 181-190). Gothenburg: Chalmers University of Technology

Smith, G., & Theseira, W. (2020). Workshop 5 report: How much regulation should disruptive transport technologies be subject to? *Research in Transportation Economics*.

Yu Faxer, A., Olausson, E., Olsson, L., Smith, G., & Pettersson, S. (2018). *Electric cargo bike with a twist-A field test of two innovative bicycle concepts*. Paper presented at EVS 31 & EVTeC 2018, 1-3 October, Kobe.

Nomenclature

Term	Meaning
Active mobility	Modes of people transport primarily using the physical activity of a human being for locomotion.
Collaborative innovation	Innovation processes through which a plurality of actors work together to innovate, despite the persistence of various forms of dissent.
Governance	The act of governing sustainability transitions and innovation processes, which includes guiding, managing, monitoring, and/or carrying out related activities.
Hands-off intervention	Governance activities which entail that the public sector focuses on coordinating and incentivizing external innovation activities.
Hands-on intervention	Governance activities which entail that the public sector participates in and oversees decision-making and operational innovation activities.
HSL	*Helsingin seudun liikenne* – The PTA in Greater Helsinki, Finland.
Innovation	A process whereby ideas are transformed into products, service, or processes that are perceived as new within a defined area and which are adopted and used.
Institutions	A relatively stable collection of rules and practices, embedded in structures of resources that make action possible.
IRIMS	Institutional fRamework for Integrated Mobility Services – A framework aimed to aid in analyses of institutional conditions for MaaS developments.
LVM	*Liikenne- ja viestintäministeriö* – The Finnish Ministry of Transport and Communications.
MaaS Integrator	A role in the MaaS value chain that entails assembling information on mobility service providers' offerings and mediating this to MaaS Operators.
MaaS Operator	A role in the MaaS value chain that entails bundling and delivering MaaS offerings to users.
MaaS	Mobility-as-a-Service – A type of service that through a joint digital channel enables users to plan, book, and pay for multiple types of mobility services.
Mobility service	A service for moving people.
Personal mobility regime	The institutional environment that structures and coordinates actors and activities in the personal mobility system.
Personal mobility system	The socio-technical system in which actors, activities, and technologies interact to provide land-based personal mobility within a given geographical area.
PTA	Public transport authority – The authority responsible for public transport planning and administration.
PTA-VG	Region Västra Götland and Västtrafik AB – Two organizations that together are responsible for public transport in Västra Götaland, Sweden.
Service regime	The institutional environment for a specific type of mobility service.
Sustainability	Meeting the needs of the present without compromising the ability of future generations to meet their own needs.
Sustainability transition	Fundamental transformations of socio-technical systems toward more sustainable modes of production and consumption.
TfNSW	Transport for New South Wales – The statutory transport and roads agency in New South Wales, Australia.

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PART I BACKGROUND & MOTIVATION

CHAPTER 1
Introduction

1.1 A Need for a Modal Shift

Transport is a means for giving people access to what they need to live healthy and fulfilled lives. Accordingly, sustainable transport systems are at the heart of accomplishing the 2030 Agenda for Sustainable Development (UN, 2015a; 2016). Indeed, one of the agenda's set targets is to provide access to safe, affordable, accessible, and sustainable transport systems for all. Yet, current transport systems fail to deliver on all these attributes.

In terms of *environmental sustainability*, the transport sector is responsible for almost a quarter of energy-related carbon dioxide emissions (Sims et al., 2014). Whilst other sectors have started to decarbonize, fossil fuels are still the dominant source of the transport sector's energy (EIA, 2016). In spite of technological advances and mitigation measures, emission levels are growing (IEA, 2019) and are expected to continue to grow (ITF, 2019). Regarding *accessibility*, current transport systems are often poorly fitted to the needs of socially disadvantaged groups in general, such as the poor, women, children, ethnic minorities, elderly, and rural dwellers (Lucas, 2012; Social Exclusion Unit, 2003). Transport disadvantage and social disadvantage interact to cause transport poverty, which leads to social exclusion, reduced wellbeing, and productivity loss (Stanley, 2019). A subset of the transport poverty problem relates to lack of transport *affordability* (Mattioli et al., 2017). Vast income inequalities (e.g. Eurostat, 2019a) lead to many households neither being able to afford a car, nor having access to other transport options (EAA, 2016). When it comes to *safety*, about 1.35 million people die annually as a result of road traffic crashes (WHO, 2018). Even more are estimated to pass away prematurely due to air pollution (OECD, 2016), sedentary lifestyles (WHO, 2017), and noise pollution (T&E, 2008): all problems to which transport is a main contributor. Beyond these mismatches with the 2030 agenda, undesirable externalities of transport include space requirements and congestion (Verhoef, 1994). Current transport systems occupy a large share of the available land in cities (Gössling et al., 2016), thus hindering alternative uses, while road congestion is a great and rising burden on citizens' time budgets (e.g. INRIX, 2018) and on the economy in general (UN, 2016).

Due to its dominant position and space and energy inefficiency, car traffic has been identified as the primary cause of these sustainability problems (e.g. Becker, 2017; Gössling et al., 2019). Accordingly, the need for reducing car dependency has been

widely recognized, and several types of measures targeting this dependency have been implemented, ranging from retrofitting streets for walking and bicycling to promoting behavioral change through advertising campaigns (Hopkins & Higham, 2016). Still, car ownership and the annual distance travelled by car continue to rise globally (e.g. Eurostat, 2019b; Trafikanalys, 2019). A tragedy of the commons situation – i.e. that the car is often the best solution for an individual albeit not for society (Vergragt & Brown, 2007) – and deeply rooted structures and practices that reinforce car ownership and use (Urry, 2004) make it difficult to shift away from automobility as the hegemonic practice of mobility (cf. Koglin, 2013).

The fifth assessment report of the Intergovernmental Panel on Climate Change identified four principle ways of tackling the carbon footprint of transport: avoiding journeys, lowering energy intensity of vehicles, reducing carbon intensity of fuels, and encouraging a modal shift to lower-carbon transport systems (Sims et al., 2014)[1]. Delimiting the scope to land-based personal mobility (the movement of people rather than the movement of goods[2]), this thesis departs from the fourth principle, i.e. the need to facilitate a shift away from private cars to more sustainable modes of mobility, such as bicycling, walking, and mobility services that favor energy efficient vehicles, shared assets, and/or shared rides.

1.2 The Promises of Mobility-as-a-Service

In recent years, Mobility-as-a-Service (MaaS) has emerged as a presumed silver bullet to personal mobility improvement. The underlying rational is that the introduction of MaaS can make it easier and more attractive for users to combine complementary mobility services and thus enable more people to satisfy their travel needs without owning or using private cars. If this is the case, it follows that MaaS can both support a modal shift away from private cars and help mobility service providers grow their businesses[3].

The term MaaS was first popularized in 2014 during the 10th European Congress on Intelligent Transport Systems in Helsinki[4]. At the time, MaaS was described as "a system, in which a comprehensive range of mobility services are provided to customers by mobility operators" (Heikkilä, 2014, p. 8). Early MaaS texts also highlighted that MaaS should be delivered via the means of a single digital interface (often in the form of a smartphone app) that enables people to plan for multimodal travelling, provides a single mechanism for payment of all included mobility services, and offers subscription plans in the form of mobility bundles (Hietanen, 2014).

To distinguish different types of MaaS services, Sochor et al. (2018a) proposed a typology of five levels of MaaS[5], where the currently typical situation of single, separate services is referred to as level zero. Level one represents *integration of information* for finding the best trips, multimodal or not. This can be realized via a multimodal journey planner or a more advanced travel assistant. Level two stands for *integration of booking and payment*. MaaS Operators at this level take responsibility for valid tickets, accurate

bookings, and the purchase processes but not for the mobility service per se, e.g. in terms of delay compensation, customer support, or validation of driver's licenses. Such responsibilities are instead introduced at level three, which represents *integration of the holistic service offering*. Level three services are bundled, possibly subscription-based, and the MaaS Operators have accountability in relation to both users and mobility providers (i.e. suppliers in this case). Finally, level four is the *integration of societal goals* via a governance framework that incentivizes sustainable mobility practices. For instance, it has been suggested that transport and land-use policies, such as parking fees, congestion charges, and dynamic road pricing could be integrated with MaaS to create new opportunities to nudge travel behavior (Holmberg et al., 2016; Wong et al., 2017).

To separate the MaaS concept from multimodal route planners (e.g. TripGo) and travel payment cards (e.g. the Oyster card) but not dictating which business or collaboration models can or should be used, this thesis draws the line at integrating information, booking and payment (i.e. level two in Sochor et al., 2018a). In other words, services must include at least these functions to be considered as a case of MaaS in this thesis. Yet, it should be noted that these three core functions only represent the minimum viable product. MaaS services should preferably address the user needs that lie beyond, or in between them as well (described as *the service of the service* in Karlsson et al., 2016). In the end, it is the users' perception of the totality of the service that may set MaaS apart from pure information or payment technologies (Hensher et al., 2020).

The thesis also takes an interest in MaaS' potential capacity to bring together several types of mobility services – such as traditional public transport, taxi, and ride sharing – but does not take a position regarding the type of actor that delivers MaaS (e.g. incumbents or new entrants). Furthermore, the potential value that MaaS can bring to users rests on the utility and usability of the included mobility services. Still, to concentrate on the integration of mobility services rather than the mobility services per se, MaaS is here considered as the medium for accessing these mobility services and not as the sum of them. Thus, in this thesis, MaaS is defined as *a type of service that through a joint digital channel enables users to plan, book, and pay for multiple types of mobility services* (see Figure 1).

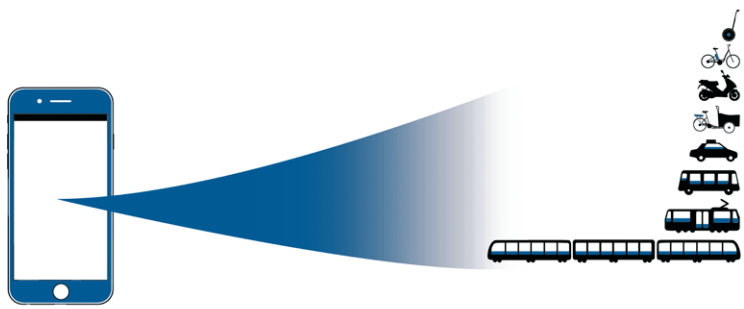

Figure 1. The central idea of MaaS, adopted from paper F

This understanding of MaaS is more inclusive and neutral than most proposed MaaS definitions[6]. It encompasses MaaS services that are delivered by any type of actor or network of actors, and which are set up with or without an explicit purpose to produce benefits to society. Furthermore, MaaS services can, according to this view, be large-scale and global as well as small-scale and local, offer pay-as-you-go and/or subscription plans, and integrate other functionalities and/or types of services, or not. As of spring 2020, examples of MaaS include Whim in Helsinki (whimapp.com), WienMobil in Wien (wienerlinien.at), Jelbi in Berlin (jelbi.de), and Zipster in Singapore (zipster.io). Whether or not these services, or MaaS in general, will justify the optimistic narratives prevalent in most other definitions of MaaS, such as user-centric (MaaS Alliance, 2017), intelligent (Kamargianni & Matyas, 2017), intuitive (MaaS Global, 2016), cost-efficient (Heikkilä, 2014), convenient (Falconer et al., 2018), comprehensive (Hietanen, 2014), seamless (Mukhtar-Landgren et al., 2016), and sustainable (König et al., 2016) remains to be seen.

Nonetheless, a main reason for the widespread public sector interest in facilitating MaaS developments (and the general MaaS hype within the transport sector) is that MaaS, in limited cases, has indeed been shown to make it easier and more attractive for users to access and use several complementary mobility services (e.g. SMILE, 2015). In particular, a six-month pilot in Gothenburg, Sweden (described in Chapter 2) indicated that MaaS can bring added value to users by making it more convenient to use a smorgasbord of mobility services (Karlsson et al., 2016), that MaaS can lower the need for car ownership (Strömberg et al., 2018), and that MaaS adoption can lead to reduced levels of car use (Sochor et al., 2016). In other words, the experiment highlighted that MaaS can be able to facilitate the needed modal shift away from private cars.

1.3 Knowledge Gaps

The scientific literature on MaaS has grown rapidly since the first MaaS pilot in Gothenburg in 2013-14. The research database Web of Science finds 125 papers published between 2015 and 2019 that use *Mobility-as-a-Service* in the title, abstract, or keywords (the corresponding numbers for Scopus and ScienceDirect are 228 and 322 respectively). Yet, at least three fundamental knowledge gaps remain.

Firstly, the understanding of what impacts MaaS can bring about under different conditions is limited. MaaS services have been trialed across western Europe (Kamargianni et al., 2016) and many more tests and operations are underway, including in Europe (e.g. I&W, 2019), North America (e.g. FTA, 2016), Asia (e.g. mobilityX, 2019), and Oceania (e.g. TfNSW, 2018b). Still, the undertaken pilots have thus far been small-scale in terms of numbers of participants and geographical coverage (Hensher et al., 2020), and few of the pilots have been systematically evaluated (Karlsson et al., 2017). Notable exemptions have doubled-down on the user appeal of MaaS (Hartikainen et al., 2019) but reported limited effects on travel behavior (e.g. Hesselgren et al., 2019; Storme et al., 2020). Nonetheless, most propositions on what user segments MaaS can attract

and how MaaS can influence their travel behavior are based on expert surveys (e.g. Jittrapirom et al., 2018b), simulations (e.g. Becker et al., 2020), and stated-preference experiments (e.g. Alonso-González et al., 2020; Caiati et al., 2020; Guidon et al., 2020; Ho et al., 2020; Matyas & Kamargianni, 2019). To validate the propositions on the effects of MaaS, comprehensive empirical analyses that investigate how MaaS influences personal mobility practices, and the socio-technical systems in which personal mobility is embedded (see Section 3.1), are needed.

Secondly, how to realize the MaaS concept is still ridden in the dark. Despite its promising results, the first MaaS pilot in Gothenburg was followed by disagreements on how to proceed after the pilot (see Chapter 2), and MaaS has in general thus far proven difficult to realize. Collaboration difficulties have appeared as the perhaps largest hindrance to MaaS developments. Inter-organizational collaboration is a necessary condition for MaaS developments (Casey & Valovirta, 2016; Jittrapirom et al., 2018a; Meurs et al., 2020; Polydoropoulou et al., 2020). Still, the high level of uncertainty surrounding the concept delays the formation of partnerships (Jittrapirom et al., 2018b), in particular across public and private sectors. Two collaboration-related issues have been contested to a higher degree than others: what types of actors should front MaaS services and take responsibility for user relations (cf. Eckhardt et al., 2017; Holmberg et al., 2016); and what types of business models are viable (cf. Aapaoja et al., 2017; Sarasini et al., 2017)? Additionally, scholars have highlighted challenges, such as putting together offerings that potential users find attractive (e.g. Jittrapirom et al., 2017), inflexible back-end systems (Meurs et al., 2020), unwillingess to share data (Polydoropoulou et al., 2018), risks of unlawful processing of personal information (Murati & Henkoja, 2019), and prevailing attitudes to car ownership amongst potential users (Mulley, 2017). Nevertheless, these findings are (again) mostly based on expert reviews and conceptual reasoning. To inform appropriate implementation practices there is a need for empirically grounded research on what drives and hinders MaaS developments.

Thirdly, public sector roles in MaaS developments are much discussed yet poorly understood; how public sector actors can and should govern MaaS developments are still open questions. Several incompatibilities between MaaS and current governance frameworks have been identified (Hensher, 2017; Laine et al., 2018; Li & Voege, 2017). This makes it challenging for the public sector to facilitate MaaS developments (Heikkilä, 2014) while also ensuring that societal benefits are produced (Docherty et al., 2018; Wong et al., 2020). Hence, MaaS seems to require novel approaches to governance. Accordingly, there is a large scope for research into how to govern MaaS (Hirschhorn et al., 2019; Mulley et al., 2019). This includes the governance challenges posed by MaaS (Pangbourne et al., 2020), how public sector actors are responding to these challenges (cf. Hirschhorn et al., 2019), and what factors shape the public sector actors' responses (Surakka et al., 2018). Most prominently though, a larger knowledge base on how different public sector activities influence the pace and trajectory of MaaS developments is needed to enable informed choices on MaaS governance (Audouin & Finger, 2018).

1.4 Aims and Research Questions

The reported doctoral thesis project departed from the need for a modal shift away from private cars, MaaS' hypothesized potential to contribute to such a modal shift, and the three knowledge gaps outlined in the previous section. However, despite the widespread interest in MaaS, MaaS developments are still nascent and yet to influence personal mobility at scale, as there are few MaaS users thus far. Consequently, it has not been possible to empirically evaluate MaaS' capacity to contribute to the needed modal shift in a meaningful way within this doctoral project (see Section 4.2). The scope of this thesis is therefore delimited to addressing the second and third knowledge gaps: how to realize MaaS, and how to govern MaaS developments.

These topics are approached from a public sector perspective. The motivation for this is two-fold. Firstly, the public sector has frequently been characterized as both a key benefactor and a key enabler of MaaS developments (e.g. Hietanen, 2014; Utriainen & Pöllänen, 2018). For example, public transport has been widely recognized as the *backbone* of MaaS (e.g. POLIS, 2017; UITP, 2016), and the support of public transport authorities (PTAs) has been identified as indispensable for MaaS experimentation (Holmberg et al., 2016). Consequently, the public sector in general, and PTAs in particular, arguably has key roles to play in MaaS developments no matter how they unfold. Secondly, many public sector actors have gained interest in MaaS in recent years and started to search for ways to accelerate MaaS developments. Thus far, they have had few readily available examples (and even less empirical evidence) to lean on when formulating their MaaS strategies. Hence, there is a prevalent demand for first-hand knowledge of how public sector activities influence MaaS developments.

Due to the embryonic state of MaaS, the most pressing challenge for the public sector at the moment is to get MaaS developments rolling. However, in this thesis MaaS is not viewed as an end in itself but as a means to potentially achieve a modal shift away from private cars to lower the negative externalities of personal mobility systems. Accordingly, this thesis's primary aim is to *devise a better understanding of how public sector actors can facilitate action in the early phases of MaaS development while also ensuring that MaaS contributes to a transition towards more sustainable transport systems*.

This aim tackles a practical problem rather than theory development. Still, the thesis draws on literature from sustainability transitions, collaborative innovation, and institutional theory to structure and make sense of the analysis (see Chapter 3). It has been noted that "nothing advances theory better than tackling a practical problem by integrating different perspectives" (Stern, 2014, p. 3). In line with that logic, the secondary aim of this thesis is to *contribute to sustainability transitions studies based on insights from the undertaken research and from other bodies of literature*.

In approaching how public sector actors can facilitate and steer MaaS developments, this thesis addresses three research questions. Firstly, the thesis seeks to understand to what extent actors involved in MaaS developments buy into the hopeful narrative that has surrounded the MaaS concept thus far (cf. Pangbourne et al., 2018; 2020). This is important to establish since expectations form ideas of how things may develop, which in turn guide policymaking and development processes (Hielscher & Kivimaa, 2019; Smith et al., 2005; van Lente, 2012). Consequently, an understanding of the expectations of different members of a system is vital to be able to develop shared, long-term visions (Hansen & Bjørkhaug, 2017), which has been identified as a key first step for providing directionality to emerging and uncertain innovations, such as MaaS (Kemp et al., 2007). Much of the current MaaS literature speculates about where a diffusion of MaaS can lead (e.g. Wittstock & Teuteberg, 2019), but little is known about possibly competing viewpoints or how confident the actors involved in MaaS developments are in their views. To attend to these issues, the first research question deals with expectations:

> **RQ1:** (a) What effects do actors involved in MaaS developments foresee that MaaS will have on personal mobility, and (b) how have these expectations influenced MaaS developments?

Secondly, to identify and remove inhibitory institutional structures and practices have been suggested as chief public sector tasks in the development and diffusion of innovations (cf. Loorbach, 2010). To effectively support innovation processes, it is moreover important to understand what institutional factors push developments (cf. Suurs, 2009). A few studies have looked into what types of barriers hamper MaaS developments (e.g. Jittrapirom et al., 2018b; Li & Voege, 2017), but these studies have generally relied on expert reviews and/or conceptual reasoning rather than on actual experiences of MaaS developments. Even less is known about how MaaS developments are motivated. To address these shortcomings, the second research question covers institutional factors:

> **RQ2:** How do institutional factors drive and hinder MaaS developments?

Thirdly, public sector actors are deploying a range of activities designed to support MaaS developments (e.g. Hirschhorn et al., 2019; Isaksson et al., 2019). A few scholars have analyzed the impacts of these (e.g. Surakka et al., 2018), but the knowledge of how public sector actors can influence MaaS developments is still limited. While acknowledging that it is too early to establish long-term consequences, this thesis sets out to begin to accumulate an understanding of the effects of different ways of governing MaaS developments. The third research question therefore focuses on public sector activities:

> **RQ3:** (a) What have public sector actors done in relation to MaaS developments, and (b) how have these activities shaped MaaS developments?

1.5 Thesis Structure

This thesis is structured into four parts. The first part, which covers Chapters 1 and 2, introduces the background to the thesis and motivates the research. To investigate the accumulated experience of MaaS thus far, the thesis uses the MaaS developments in Västra Götaland in western Sweden as a starting point. The first comprehensive MaaS pilot took place here in 2013-2014, and the regional PTA has since worked actively to pave the way for further MaaS developments. This empirical background is introduced in Chapter 2, providing further motivation to the thesis' aims and research questions.

The second part describes the research approach. The frame of reference is provided in Chapter 3. Departing from the literature on sustainability transitions, the development, diffusion, and use of MaaS is conceptualized as an innovation process, which might trigger regime transitions in personal mobility systems. As explained throughout the chapter, this process coexists and coevolves with governance activities and institutional environments. Chapter 4 describes the research design. This includes theoretical assumptions and the methodological approach as well as the empirical studies on which the thesis is built. The empirical studies encompass three cases of MaaS developments involving the regional PTA in Västra Götaland between 2016 and 2019 and two cases of MaaS developments situated in Finland (2017) and Australia (2018) respectively. An overview of how the cross-study analysis was performed is also provided here.

Subsequently, the third part provides the thesis' findings. Chapters 5, 6, and 7 present the analysis and results for each of the research questions respectively. Chapter 5 outlines expectations of how MaaS will transform personal mobility, including anticipated effects on service systems and the alignments between service regimes (RQ1). How institutional drivers and barriers influence MaaS developments is presented in Chapter 6 (RQ2). Thereafter, Chapter 7 focuses on what public sector actors have done in relation to MaaS, and how these activities have shaped MaaS developments thus far (RQ3).

Finally, the fourth part proposes implications and discusses the thesis' contributions. Departing from the evidence from the empirical studies, Chapter 8 proposes implications for transport governance in the form of MaaS governance principles and pathways while Chapter 9 concludes by reflecting on the research approach, the thesis' knowledge contribution, and future research directions.

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1. Cf. the *avoid*, *shift*, and *improve* strategies outlined in Hickman and Banister (2019).
2. Sometimes also denoted as *passenger transport* (OECD, 2019) or *corporeal travel* (Urry, 2007).
3. Other central notions are that MaaS can match mobility service supply and demand by closing information gaps (Guidon et al., 2020) and overcome the separation of fixed and marginal mobility costs, thus allowing more cost-aware travel behavior (Becker et al., 2020).
4. Yet, MaaS is closely related to preceding concepts, such as *combined mobility* (UITP, 2011) and *integrated mobility solutions* (UITP, 2016).
5. An overlapping typology has been developed by Lyons et al. (2020).
6. See Karlsson (2016) and Sochor et al. (2018a) for overviews of MaaS related definitions.

CHAPTER 2

Empirical Background

Västra Götaland is a region located on the west coast of Sweden. The region, which is subdivided into 49 municipalities has a population of about 1.7 million residents and is thus the second most populated region in Sweden. Following the introduction of a new public transport law in 2012 (SFS, 2010), the organization Region Västra Götaland became responsible for developing and operating the public transport network in Västra Götaland. The formal PTA is a political body, the Public Transport Committee (Swedish: *Kollektivtrafiknämnden*), while Västtrafik AB, a company fully owned by Region Västra Götaland, plans and procures a level of service, which in turn is delivered to users by the procured private operators. To not get bogged down in local organizational arrangements, Region Västra Götaland, the Public Transport Committee, and Västtrafik AB are treated as one organization in this thesis, namely the PTA of Västra Götaland (called PTA-VG hereafter).

One of PTA-VG's central steering documents is the regional transport program. Its overall goal for 2025 is that "the share of 'sustainable travel' is increasing throughout Västra Götaland and the market share of public transport is doubled [compared to 2006]" (VGR, 2016, p. 1). In addition to public transport, the program recognizes walking and cycling as sustainable transport modes. In 2018, the total modal share for these three modes was estimated at 39% (VGR, 2019a). While the numbers for walking and cycling are somewhat uncertain, the number of public transport trips has grown 69% since 2006, following comprehensive investments in the public transport system and its infrastructure (ibid.). Hence, the public transport growth is thus far in line with the 2025 goal.

However, in recent decades, costs for public transport provision in Sweden have increased faster than both the use of public transport and the revenues from taxes and tickets (Vigren, 2015; 2016), so also in Västra Götaland. To address the long-term financing of the transformation towards more sustainable travel behavior, the regional transport program states that continued strong investments in public transport as well as the identification of new funding sources and the implementation of new cost-effective approaches are needed (VGR, 2016). The two latter points were the underpinning motive for PTA-VG's initial and continuous interests in exploring MaaS.

Financed and managed by PTA-VG, a pre-study project entitled The Flexible Traveler (Swedish: *Den flexible trafikanten*) introduced the concept of MaaS to Västra Götaland

in 2011. The pre-study suggested that MaaS services, if comprehensive, reliable, and personalized, can reduce transport costs, increase perceived transport flexibility, and contribute to more sustainable travel behavior for family households and small companies in the urban areas of Västra Götaland. It was also concluded that the institutional conditions were in place for MaaS. Yet, it was noted that the involved public transport actors were perceived as more interested in continuing current pathways than in disrupting their roles (Boethius & Arby, 2011).

The MaaS concept proposed by the pre-study was further developed in a two-phased research and development project named Go:Smart (LSP, 2014). The second phase of the project comprised a pilot, UbiGo, which is frequently referred to as the world's first comprehensive example of MaaS. Seventy-one households located in or in the vicinity of Gothenburg were recruited to participate in the pilot[1]. Customized and modifiable subscription plans, invoiced on a monthly basis, were developed for each of these households, and each person used a prototype smartphone app through which they could access public transport tickets and book car sharing, bicycle sharing, rental cars, and taxis. Using these tools, the households solved their everyday travel needs for six months (November 2013 – April 2014) and reported their travel behavior and experiences via questionnaires, interviews, and focus groups, and a subset filled out travel diaries.

The average monthly subscription for a household was approximately €175 in today's value (Sochor et al., 2016). They mostly spent this on public transport, car sharing, and car rental (Sochor et al., 2015b). Moreover, 80 participants joined the bicycle sharing system (ibid.). Generally, UbiGo was found to help the participants try out unfamiliar mobility modes (Strömberg et al., 2016) and to make multi-modal travelling less expensive and more convenient (Sochor et al., 2015a). Consequently, the service was widely appreciated among the participants; 80% wanted to become customers if the service would start up again (Sochor et al., 2014). The service also seemed to promote changes in the participating households' travel behavior towards more use of the included mobility services and active modes at the expense of private car use. Twenty private cars were set aside during the experiment[2] (17 of which were from single-car households) and 48% of the participants reported a decreased use of private cars (Sochor et al., 2015b). Hence, the experiment was deemed to illustrate that MaaS can be a tool for reducing car ownership and use.

A company named UbiGo AB[3] was established to refine and commercialize the trialed service. However, the Go:Smart project report concluded that the project "time was not enough for all processes and the view of the future solution was not sufficiently anchored in all project partners" (LSP, 2014, p. 9). This resulted in the commercialization process coming to a halt. The different takes on the pathway forward primarily explored whether it was possible to extend the ongoing collaboration or not. PTA-VG argued that this was not possible as it would violate public procurement acts and that it had to evaluate the potential implications of different roles in the operational value chain.

To examine these matters for realizing the MaaS concept on a regional scale, PTA-VG performed an investigation shortly after the Go:Smart project was finalized (Västtrafik, 2014). Five strategies were identified: *await market developments* entailed that PTA-VG would initially take a passive role to possibly get involved at a later stage, *making the offering available* entailed that PTA-VG would help the private market develop MaaS services by opening digital interfaces for data and tickets but not intervene beyond that, *stimulate the market* entailed that PTA-VG would initiate a pre-commercial procurement process to inject money into the MaaS market[4], *operator closely associated with PTA-VG* entailed that a private actor strongly associated with PTA-VG would be contracted via a service concession agreement[5], and *public procurement* entailed that PTA-VG would procure a MaaS service for Västra Götaland based on the trialed MaaS model.

The strategies were analyzed based on how well they favored innovation, estimated time to market, cost-effectiveness, national scalability, how they might impact PTA-VG's brand, and legal aspects. The investigation concluded that strategy four (operator closely associated with PTA-VG) was best suited to deliver a cost-effective MaaS service for Västra Götaland that contributed to increased sustainable travelling and an improved perception of PTA-VG's brand (Västtrafik, 2014). Accordingly, this strategy was adopted, and following a period of inaction, PTA-VG initiated a procurement process in spring 2016.

Some parties vigorously contested PTA-VG's strategy choice, especially several of the actors involved in the Go:Smart project who felt that PTA-VG was being protective and risk averse, and was acting as a *wet blanket* regarding MaaS developments by deciding to procure a new MaaS service instead of extending the already trialed service. Additionally, far from everyone at PTA-VG were themselves convinced that PTA-VG should support MaaS at all. Concerns included the risk that MaaS will reduce PTA-VG's control over user relationships and/or help other mobility service providers cannibalize from the public transport modal share. Consequently, PTA-VG perceived a need for a more long-term and structured analysis of what role PTA-VG, and the public sector in general, could and should play both in MaaS developments as well as in a future, integrated personal mobility system. In other words, PTA-VG wanted a larger knowledge base on which to make informed, long-term, strategic decisions regarding how to govern MaaS. Drawing on this need, PTA-VG decided to complement and support the ongoing efforts to realize MaaS by employing an industrial doctoral student (VGR, 2015). Accordingly, the doctoral project culminating in this thesis was initiated just before PTA-VG entered the procurement process in spring 2016.

1. Additionally, ten households connected to people in the project team used the service during the pilot.
2. The households were given the possibility to set their car aside, with some economic compensation.
3. UbiGo AB closed down in 2014. UbiGo Innovation AB, a new company with the mission of refining and relaunching the piloted service, replaced it later the same year.
4. A multi-stage process where the procurer can interrupt the process after each stage (Vinnova, 2013).
5. Agreements through which the execution of an assignment is entrusted to one or more suppliers, and the remuneration only consists of the right to use resources made available (SFS, 2016:1147).

PART 2 RESEARCH APPROACH

CHAPTER 3
Frame of Reference

This chapter explains and motivates how theories are applied in this thesis. Broadly, the thesis primarily aims to contribute to the emerging literature on MaaS (and thus to MaaS-related policy-making and practice) but draws on theoretical constructs from several other bodies of literature to organize the analysis and to make sense of the findings. Inspired by Kanger and Schot (2019), the theoretical foundation is based on concepts from a wide variety of sources that were considered useful for analyzing what public sector actors can do to both facilitate action in the early phases of MaaS development and ensure that, in the long term, MaaS contributes to a modal shift away from private cars. Such theoretical license carries risks of conceptual incompatibility, incoherence, and inconsistency. However, it has also been noted that integrative conceptual approaches bring many different assumptions into play and can aid theoretical triangulation, thereby minimizing researcher bias, tightening analytical concepts, and opening for novel insights (e.g. Hopkins et al., 2020; Sovacool & Hess, 2017). As is illustrated throughout this chapter, this collection of theoretical concepts accommodates ample analyses related to the three research questions in a way that a single theoretical perspective may not have.

Yet, the theoretical approach is not faultless. It most notably draws on two bodies of literature: sustainability transitions studies and collaborative innovation. Both these literatures are normative and prescriptive in nature. They moreover share some weaknesses, such as a tendency to be overly optimistic about the merits of inter-organizational collaboration as well as a lack of consideration of politics and power relations (e.g. Kern & Rogge, 2018; Wegrich, 2019). For example, Gillard et al. (2016) question the very idea of purposively governing changes in complex socio-technical systems, which underpins both literatures: "the institutionalized ideas and power relations that provoke/mediate/resist social change are grossly underappreciated by a governance style that breaks society down into broadly consensual, experimental, and self-organizing systems" (p. 253). As such, the presented analysis should be interpreted in the light of these limitations, and as Section 9.4 points out, critical examinations of MaaS developments based on theories with more nuanced understandings of how power and politics relate to change, stability, structure, and agency would complement and refine this thesis' findings.

However, to preempt criticism about the theoretical approach being overly *managerial*, two key starting points for the analysis should be mentioned. Firstly, rather than implying that MaaS developments can be controlled, the thesis seeks to analyze how the public sector can influence them, while recognizing that every attempt to do so is fallible (cf. Avelino & Grin, 2017). The governance system is intertwined with the MaaS developments, and is only one of many factors that influence them (cf. Loorbach, 2007). Secondly, the studied socio-technical systems are complex and adaptive, meaning that their behaviors cannot be understood by simply analyzing the interactions of their components (cf. de Haan & Rotmans, 2011). Hence, from this point of view, every attempt to objectively and fully explain MaaS developments is bound to fall short (cf. Avelino & Grin, 2017). The frame of reference is therefore used to structure the analysis, but does not attempt to introduce a complete theory that pinpoint causal relationships between MaaS governance and MaaS developments (see Section 4.1).

Next, the conceptualizations of MaaS and MaaS developments are provided and explained. Thereafter, the theoretical concepts that have been applied to analyze and make sense of MaaS developments and MaaS governance approaches are introduced. Finally, the frame of reference is summarized.

3.1 Conceptualizing Mobility-as-a-Service

MaaS is often depicted as a new transport paradigm (e.g. Finger et al., 2015; Huhtala-Jenks & Forsblom, 2015; Rantasila, 2015). According to Kuhn's (1962) definition of paradigms, MaaS can thus be understood as a new thought pattern regarding transport that is not only distinct from current thought patterns, but also incommensurable with them. Approaching MaaS from a user perspective, this understanding of MaaS seems flawed. Firstly, MaaS is not a new thought pattern in itself, but rather a service model that can entail or embrace wider trends, such as decreased asset ownership or increased smartphone use (Sochor & Sarasini, 2017). Secondly, it is not suggested that MaaS will cause incommensurable modifications to transport systems, like the introduction of new vehicles that are incompatible with the existing physical infrastructure. The envisioned effects for users can rather be described as evolutionary changes to how existing and emerging transport infrastructures, services, and vehicles are accessed and utilized (Lyons et al., 2020). Accordingly, this thesis comprehends MaaS as a new type of service and not as a new transport paradigm per se (see Section 1.2).

Nonetheless, MaaS may contribute to paradigmatic changes to personal mobility systems. MaaS developments are anticipated to cause quite fundamental shifts in how mobility services are produced and delivered, especially in terms of increased inter-organizational collaboration (e.g. Kamargianni & Matyas, 2017). MaaS introduces new roles to the operational value chain for mobility services, which here are referred to as *MaaS Integrators* and *MaaS Operators*. MaaS Integrators assemble information on mobility service providers' offerings and mediate this to MaaS Operators, which in turn bundle

and deliver MaaS offerings to users. One or several actors can adopt the new operational roles, and these actors can either stem from current personal mobility systems or not. Either way, the introduction of the new roles is bound to disrupt inter-organizational relations, as illustrated in Figure 2.

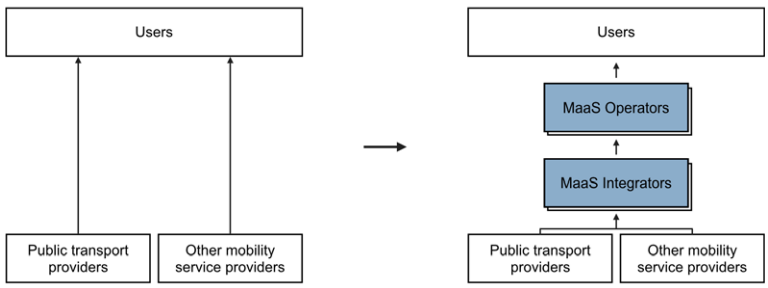

Figure 2. Emerging value chain for Mobility-as-a-Service, adopted from Paper A

Accordingly, MaaS developments could trigger transformative changes towards increased coordination and alignment across service types in the planning, design, and operation of mobility services. The underpinning and often explicitly stated hope is that this reconfiguration would facilitate a reduction in private car dependency and use (cf. Jittrapirom et al., 2018b) which in turn would be replaced with an increased use of mobility services and active modes. MaaS developments may therefore, in the long term, change the institutional environment for personal mobility. Approaching MaaS from a personal mobility system perspective, MaaS developments can thus be conceptualized to potentially contribute to a *sustainability transition*.

Sustainability transitions have been described as changes from one *socio-technical regime* to another which in turn cause fundamental transformations of *socio-technical systems* toward more sustainable modes of production and consumption (Geels & Schot, 2007; Markard et al., 2012). Socio-technical systems are often operationalized as organizational fields, which encompass the totality of actors relevant for the fulfillment of a societal function like education or healthcare (Fünfschilling, 2014). Socio-technical regimes constitute the institutional environments that give stability and meaning to the actors within these systems (DiMaggio & Powell, 1983; Fünfschilling & Truffer, 2014) and can be further divided into two separate but inter-related levels: *sectorial regimes* and *service regimes*. Sectorial regimes refer to the institutional environment that structures societal functions, while service regimes represent the level of service provision and form around specific institutionalized combinations of technologies, user routines, and organizational forms for providing particular types of services (van Welie et al., 2018).

Sustainability transitions studies broadly aim to explain how sustainability transitions have unfolded in the past, are unfolding in the present, and can be governed to unfold

in the future (Köhler et al., 2019). To examine these issues of stability and change, scholars within this research stream have traditionally studied the introduction of new technologies, such as the replacement of horse-drawn carriages with automobiles (e.g. Geels, 2005) and the shift to renewable energy sources (e.g. Verbong & Geels, 2007). Based on these studies, it has been noted that sustainability transitions typically take decades to unfold, entail multiple interdependent developments, and are enacted by a range of competing actors and agencies (Köhler et al., 2019). Sustainability transitions are moreover profoundly uncertain since it is next to impossible to predict which promising innovations will prevail and since the transitions can take many different pathways. A sustainability transition may completely replace the prevailing socio-technical regime, but could also partially influence it by modifying its basic principles or transforming its development path (Geels & Schot, 2007). For example, a new technology must not necessarily compete with the dominant technologies but could enter into new combinations with them and thus cause new problems and open new opportunities, such as in the case of electric-hybrid vehicles (Geels & Kemp, 2012).

One of the most fundamental concepts within sustainable transition studies is the Multi-Level Perspective (cf. Geels, 2002; Rip & Kemp, 1998). In short, it argues that innovations can only reconfigure socio-technical systems if change processes across three analytical socio-technical levels are aligned and mutually reinforcing: *landscapes*, *regimes,* and *niches* (Geels, 2002). The landscape includes elements that are beyond the direct influence of the actors on regime and niche levels (i.e. exogenous to the model). Developments at this level, such as changes to the climate or macro-economic circumstances, can cause the regimes to destabilize. This creates a window of opportunity for niche innovations to develop and diffuse and in the long turn either transform or replace the prevailing regime (Markard et al., 2012). The niches are assumed to be the place in which disruptive innovation take place and have been conceptualized as protected spaces in which the innovations can develop without being subject to the selection pressure of existing regimes (Kemp et al., 1998). Commonly cited carriers of niches include strategic investments in research and development, demonstration programs, and special interests communities (Raven et al., 2016).

Departing from the Multi-Level Perspective, MaaS can be conceptualized as a niche-level innovation that aims to change *personal mobility regimes*, i.e. the institutional environments that structure and coordinate actors and activities in *personal mobility systems*. A personal mobility system is here operationalized as the organizational field in which actors and activities interact with technologies to provide land-based personal mobility within a given geographical area (i.e. a subsystem of the general transport system). Thus, it encompasses the modes that MaaS is anticipated to strengthen (primarily mobility services and active modes) as well as weaken (primarily private cars). Personal mobility regimes thus constitute all the structures and practices that have considerable effects on personal mobility (cf. Fünfschilling & Truffer, 2014), including the institutional environments for specific types of mobility (i.e. the service regimes).

As noted earlier, MaaS is an integrative service concept focused on increasing the links across mobility services that are currently planned, operated, and managed with little synchronization. MaaS can thus be understood as targeting the *alignments* between the service regimes within personal mobility systems. Alignment is here defined as a function of the complementarities between personal mobility modes and the inter-operability between the different service systems (cf. van Welie et al., 2018). In summary, from a public sector perspective, the main motive of introducing MaaS can thus be understood as *to transform personal mobility systems from mostly fragmented to more polycentric, with the intent of reaping sustainability improvements by altering the personal mobility modal split*. The potential sustainability improvements from this prospective sustainability transition may or may not be directly fed back to the personal mobility systems. For instance, direct benefits could be reduced congestion, improved accessibility, or better public cost-effectiveness for personal mobility, whilst indirect benefits could be improved public health or lowered greenhouse gas emissions (see Figure 3).

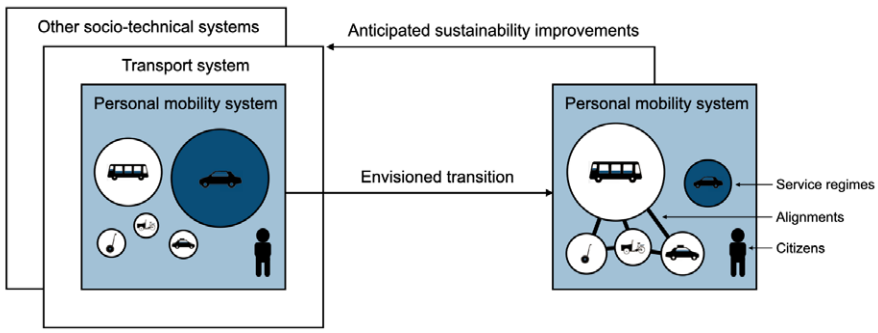

Figure 3. Conceptual model of the effects of Mobility-as-a-Service developments, adopted from Paper F

This understanding of MaaS and its potential impacts on personal mobility systems is most noticeably utilized to analyze expectations of MaaS – RQ1: (a) What effects do actors involved in MaaS developments foresee that MaaS will have on personal mobility, and (b) how have these expectations influenced MaaS developments? The approach resembles the conceptualization of inter-modality in Parkhurst et al. (2012), which concluded that the niche of inter-modal travelling is caught between a web of service regimes and not strong enough to threaten any of them. Yet, two key aspects set this thesis' approach apart: this thesis centers on a specific innovation (MaaS), and considers both inter-modal and mono-modal trips (e.g. multi-modal travelling). The operationalization of personal mobility systems in this thesis moreover clearly embraces a large array of service systems, while Parkhurst et al. (2012) mostly focused on private cars and public transport. Thus, this thesis may consider more of the factors that influence multi-modal travelling. Still, the scope of this thesis is for practical purposes delimited to land-based personal mobility within a given area, although it acknowledges that many factors outside this sub-system can influence MaaS developments (cf. Lyons, 2012; Zijlstra & Avelino, 2012).

3.2 Making Sense of Mobility-as-a-Service Developments

MaaS' potential contribution to the type of transition illustrated in the previous section is contingent on realizing the MaaS concept. In this thesis, this realization is referred to as *MaaS developments*, which serves as the main unit of observation. It is moreover conceptualized as an innovation process.

Innovation is a value-laden term with multiple meanings (Schwanen, 2016). Departing from Rogers (1995) and Baregheh et al. (2009), innovation is in this thesis understood to be a multi-stage process whereby ideas are transformed into products, services, or processes that are adopted and used, and which are perceived as new within a defined area. Following this view, and as shown in Figure 4, MaaS developments can be divided into three interrelated core phases. The *MaaS development phase* encompasses the actions taken to transform the idea of MaaS into an operational service. This comprises activities directly related to the design of MaaS services (cf. Stickdorn et al., 2018) as well as activities that relate to the institutions that influence the development (cf. Bergek et al., 2008). Subsequently, the *MaaS diffusion phase* covers the process by which people get to know MaaS services and decide to adopt them or not. This includes potential users being exposed to MaaS services, forming attitudes toward MaaS, engaging in activities that lead to a choice to adopt or reject MaaS, starting to put MaaS to use, and seeking reinforcement for this decision (cf. Rogers, 1995; Strömberg, 2015). Hence, the MaaS diffusion phase partly overlaps with the *MaaS use phase*, which constitutes the state when the use of MaaS is stabilized and has become a mainstream part of the personal mobility system. Due to the project circumstances outlined in Section 1.4, this thesis is delimited to analyzing the MaaS development and MaaS diffusion phases.

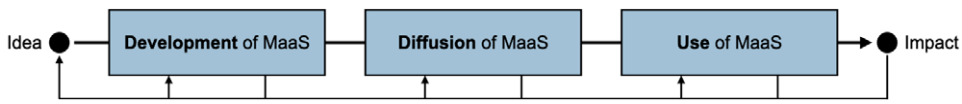

Figure 4. Core phases in the MaaS innovation process, inspired by Edquist (2004)

The three phases of MaaS developments might engage the same set of actors, but the actor constellations can also be more or less separate (cf. Bergek, 2019). For example, innovation agencies could support MaaS development and diffusion, but not be involved in the continuous operation of MaaS (i.e. the MaaS use phase). Three potentially overlapping actor types that may influence the three phases of MaaS developments are recognized here. Firstly, people are the ones that will have the final say on whether or not MaaS is successful, since they are the intended adopters (in most cases). People are primarily considered as a heterogeneous and co-evolving group of *users* of MaaS (cf. Randelli & Rocchi, 2017), but also as potential co-creators, co-implementers, and co-evaluators, as well as non-using citizens, voters, and tax-payers. Secondly, *operational actors* either perform operational

development and diffusion activities and/or have practical responsibilities in the continuous delivery of MaaS. This actor type could for example encompass a technology provider that develops the back-end infrastructure for a MaaS service, an advertising agency that markets a MaaS service, or a taxi company that provides its offering to a MaaS service. Thirdly, *strategic actors* influence the institutional conditions that both enable and constrain MaaS developments. This actor type could include universities producing MaaS knowledge, governments reforming transport regulation, venture capitalists investing in MaaS businesses, intermediaries orchestrating MaaS-related collaborations, or trade unions for transport workers that act to protect their members' rights.

The last actor type is relevant to include since MaaS developments are entrenched in *institutions* (cf. Geels & Schot, 2007). Institutions are here loosely understood as "a relatively stable collection of rules and practices, embedded in structures of resources that make action possible" (March & Olsen, 1989, p. 39). Three pillars that make up and support institutions comprise *the regulative pillar* that prescribes legally sanctioned rules for specific actors in specific situations; *the normative pillar* that creates morally governed expectations on behavior and explains, justifies, and legitimates behavioral codes; and *the cultural-cognitive pillar* that depicts common beliefs and shared logics of action (Scott, 2014). These pillars are conveyed through symbolic systems, relational systems, activities, and artifacts (ibid.). Hence, institutions contain both symbolic components such as ideation, meaning, and culture (here referred to as informal institutional factors) and material components such as structures, practices, and physical objects (here referred to as formal institutional factors) (Jones et al., 2013). Empirically, this implies that a diversity of tangible and intangible factors must be investigated to describe institutional environments.

The institutional perspective has been hailed as important to understand both innovation processes and sustainability transitions since it draws attention to organizational and cultural conditions (Hartley et al., 2013) and addresses questions of societal change without a specific focus on technology (Fünfschilling, 2014). In this thesis, an institutional perspective is employed to analyze the factors influencing MaaS developments – RQ2: How do institutional factors drive and hinder MaaS developments? The Institutional fRamework for Integrated Mobility Services (IRIMS) (Mukhtar-Landgren et al., 2016) is utilized to organize this analysis. It was considered appropriate for the task as it departs from a broad understanding of institutions and encompasses both factors that impede MaaS developments (here called barriers) and factors that enable and push MaaS developments (here called drivers). Furthermore, it was explicitly developed to facilitate analyses of institutional environments for MaaS developments and is thus designed for this specific type of analysis (cf. Karlsson et al., 2020).

Departing from the works of March and Olsen (1989) and Scott (2014), the IRIMS framework recognizes that institutional factors can be either formal or informal, and arise from three levels: *macro*, *meso*, and *micro*. The macro level is the umbrella dimension under which the two other levels operate. It focuses on the larger societal scale and thus

encompasses legal frameworks as well as social and cultural norms. International and national actors taking strategic roles are conceptualized to act at this level. The meso level refers to the network of strategic and operational actors at regional and local levels and their interactions. Among other things, institutional factors at the meso level comprise how national policies are implemented regionally and locally. The IRIMS framework moreover highlights the culture of collaboration and business models as two aspects that are particularly relevant to understand actors' motives and relationships at this level. Finally, the micro level places people at center stage, primarily by focusing on their prospective roles as users of MaaS. Here, institutional factors refer to individual aspects, such as current travel patterns and households' financial situations (Mukhtar-Landgren et al., 2016).

As noted in Section 1.3, the extant literature on MaaS has already identified several institutional factors that impede the development and diffusion of MaaS. This suggests that realizing MaaS is a multifaceted and challenging endeavor. It has been noted that the more demanding an innovation processes is, the greater is the importance of effective governance that catalyzes action and provides directionality (cf. Mazzucato, 2016). Hence, how to govern MaaS developments seems to be a complex yet important topic. As illustrated in Chapter 2, MaaS developments require coordinated actions from multiple strategic actors, operational actors, and users. MaaS scholars have therefore highlighted the need for inter-organizational collaboration spanning both over sectors (e.g. Jittrapirom et al., 2018b) and geographies (e.g. Merkert et al., 2020). To conceptualize how such multi-actor processes can be governed, the thesis now turns to the bodies of literature on *collaborative innovation* and *transition management*.

3.3 Governing Mobility-as-a-Service Developments

Collaborative innovation has been defined as an "externally focused, collaborative approach to innovation and problem solving in the public sector that relies on harnessing the resources and the creativity of external networks and communities (including citizen networks as well as networks of nonprofits and private corporations) to amplify or enhance the innovation speed as well as the range and quality of innovation outcomes (or solutions)" (Nambisan, 2008, p. 11). Hence, collaborative innovation essentially describes innovation processes through which a plurality of public, private, and social sector actors work together to innovate despite the persistence of various forms of dissent (Torfing, 2016). Similar to open innovation (cf. Chesbrough, 2003), the core arguments for this type of approach to public innovation are that the locus of innovation in each phase of the innovation process should be determined by the ability to perform the tasks at hand rather than by formal boundaries (cf. Bommert, 2010); moreover, that inter-organizational collaboration can strengthen all phases of innovation processes (cf. Sørensen & Torfing, 2011; Torfing, 2019). However, in contrast to open innovation, collaborative innovation centers on the production of public value rather than on generating revenue for private firms and is thus better aligned with the focus of this thesis (see Section 1.4).

The notion of collaborative innovation emerged within the broader literature on new public governance, which is a public administration theory based on the idea of a plural and pluralist state and that emphasizes inter-sectorial collaboration in networks of interdependent but more or less autonomous actors as a key method for policymaking and implementation (Osborne, 2006; Rhodes, 1997). Hence, collaborative innovation aims to transcend the binary interpretation that public innovation can be driven either by the public sector through command and control logics or by the private sector via market competition. Instead, collaborative innovation aims to bring together a range of actors with different vantage points "in interactive arenas that facilitate the cross-fertilization of ideas, mutual and transformative learning, and the development of joint ownership of new solutions" (Hartley et al., 2013, p. 828). Such arenas are thought to spur innovation by expanding the area of search, fostering inter-organizational trust, and reducing implementation resistance (Torfing, 2016).

However, multiple institutional barriers hamper public-private innovation collaborations. This includes the formal rules and multi-layered hierarchies of public sector actors (Sørensen & Torfing, 2012), and the embedded differences across public and private sectors (Munksgaard et al., 2012). Consequently, collaborative innovation is no panacea for public innovation. Even if a collaborative approach is suitable in theory, it could be difficult to motivate relevant actors to interact as well as to translate interaction into collaboration and subsequently innovation (Hartley et al., 2013; Torfing, 2016). To overcome these challenges, collaborative innovation has been argued to demand new types of public innovation governance that combine *hands-off* and *hands-on* activities (Sørensen & Torfing, 2011; 2016).

Hands-off governance activities entail that the public sector focuses on coordinating and incentivizing external innovation activities (Vento, 2019). Innovation decision-making and operational innovation activities are thus decentralized to some degree. This is thought to create freedom for the private sector to innovate, while the public sector can use incentives and pressure mechanisms to push actor networks to produce wanted innovation outputs (Osborne & Brown, 2013). Sørensen and Torfing (2009) suggested that network design and network framing are effective hands-off governance activities in this regard (cf. the notion of metagovernance in Kooiman, 2003). Still, despite the appeal of hands-off activities, scholars have noted a tendency to reintroduce traditional hands-on governance tools to innovation collaborations to reduce uncertainty and reinstate control (Ek Österberg & Qvist, 2018). Examples here include introducing elements of hierarchy and process rules and restricting what actors are involved (ibid.). Generally, hands-on governance activities entail that the public sector participates in and oversees decision-making and operational innovation activities (Vento, 2019). This is assumed to generate public sector accountability and control. Since the public sector holds unique knowledge and capabilities, it has also been noted that direct involvement of the public sector can enhance innovation outcomes (e.g. Ansell & Gash, 2008; Vento, 2019). In summary, the collaborative innovation literature recognizes that public sector actors can

take different roles in relation to collaborative innovation processes, ranging from active to passive involvement and from performing or co-performing operational innovation activities (cf. operational actor) to setting the boundary conditions for innovation through hands-on and hands-off interventions (cf. strategic actor).

Similar to the literature on collaborative innovation, sustainability transitions studies depart from the notion that traditional approaches to public innovation are insufficient when it comes to the comprehensive problems in today's society (Smith et al., 2005). Correspondingly, multiple frameworks for analyzing and advising how to influence innovation processes and sustainability transitions have been proposed within this research field. One that has received considerable attention is the Transition Management Framework: a normative, collaborative, prescriptive, and iterative approach to governing transitions that can be used as either an analytical lens or as an operational management tool (Kemp et al., 2007; Loorbach, 2007). The framework was developed in close collaboration with the Dutch government in the beginning of the 21st century (Rotmans et al., 2001). The core idea is to bring so called frontrunners from public, private, and social sectors, and academia together to develop a shared understanding of the transition challenge in focus, to develop a collective vision and an agenda for addressing it, and to catalyze strategic experiments (Wittmayer & Loorbach, 2016). Guiding principles include a focus on long-term thinking with intermediate flexible short-term objectives at the socio-technical system level, governing from both outside and inside these systems, and an emphasis on joint learning processes and interactions between actors (Loorbach, 2010). The framework moreover pinpoints four types of governance activities – *strategic*, *tactical*, *operational*, and *reflexive* – and argues that a mix of them is needed to create space for short-term innovation activities that can contribute to the desired long-term transition, if the activities are performed in an integrated and iterative manner.

Strategic activities aim to establish a transition arena through which shared long-term visions and images are developed and discussed. The main objective is that involved actors should get a better understanding of the nature of the problem and the perspectives held by other actors and adjust their problem definitions and perceptions accordingly (Kemp & Loorbach, 2006). In other words, the underlying logic is to create a discourse that can influence the overall innovation trajectory and inspire a broad movement (Loorbach, 2007). To accomplish this, activities at this level should, according to the Transition Management Framework, include collective visioning and goal formulation for a time frame of one to three generations (Rotmans et al., 2001). Furthermore, to generate support from a wide range of different actors, these visions and goals should preferably be communicated in the form of appealing and imaginative socio-technical scenarios.

Tactical governance activities relate to the build-up and break down of system structures and link individual actors' and sub-systems' action plans to the long-term vision (Loorbach, 2010). The transition management literature highlights participatory

back-casting as a primary technique for exploring transition pathways and identifying important activities at this level (Vergragt & Quist, 2011). Preferably, actors that have capacity to translate the common transition agenda to roadmaps for their own sub-system or organization should be involved in this work (Loorbach, 2010). It has been argued that these roadmaps should predominantly focus on mid-term changes in formal structures like regulations and infrastructures (Wittmayer & Loorbach, 2016).

Operational activities center on short-term transition experiments. Linked to the transition challenge, transition experiments explore new ways of doing, thinking, and organizing to generate new knowledge through projects, pilots, and implementations (cf. Kemp et al., 2007; van den Bosch, 2010). Transition experiments diverge from classical innovation experiments since they depart from uncertain and complex transition challenges rather than from possible solutions, their objectives are to contribute to a long-term transition rather than identifying a satisfactory solution, and they center on higher-order learning (cf. Engeström, 1987). In addition, transition experiments should preferably be explorative in nature, take place in real-life contexts, be performed by multi-actor alliances, and be governed based on the transition management principles (van den Bosch, 2010).

Finally, reflexive activities should, according to the Transition Management Framework, take place throughout the transition processes. These activates are aimed at monitoring and evaluating the transition and the applied governance activities (Loorbach, 2010). Due to its reliance on knowledge integration, anticipation of long-term systemic effects, adaptiveness of strategies, iterative participatory goal formulation, and interactive strategy development, transition management is often described as a reflexive governance approach in itself (e.g. Kemp & Loorbach, 2006). Still, it has been argued that transition management approaches should encompass distinct reflexive governance activities, which aim at achieving higher-order learning from other governance activities and at adapting these based on the generated insights (Loorbach, 2010).

The Transition Management Framework has been found to help public sector actors redefine, reimagine, and reshape how they govern sustainability transitions (e.g. Jhagroe & Loorbach, 2018) and to support robust analysis of governance approaches (Wieczorek, 2018). For this thesis, it provides a way to categorize governance activities based on their time scale and is thus a straightforward tool for assessing MaaS policy programs. However, it does not provide a good mechanism for describing the method of public sector intervention. To describe these different methods of intervention, the Transition Management Framework is therefore complemented with the classification of hands-on and hands-off governance activities from the collaborative innovation literature in the analysis of how public sector actors attempt to influence MaaS developments – RQ3: (a) What have public sector actors done in relation to MaaS developments, and (b) how have these activities shaped MaaS developments?

3.4 Summary

MaaS is in the thesis understood as a new type of service, while MaaS developments are conceptualized as a niche-level innovation process that might contribute to transforming personal mobility systems. From a public sector perspective, the main underpinning motive of this prospective transformation is to trigger a modal shift within personal mobility, which is in turn anticipated to result in sustainability improvements. Due to the long-term perspective, directionality, and systems perspective of this potential transformation, the literature on sustainability transitions was deemed appropriate for organizing the analysis of expectations on MaaS developments (RQ1). The MaaS developments are moreover enabled and constrained by institutional structures and practices. To analyze these (RQ2), this thesis adopts an analytical framework (IRIMS) that is rooted in institutional theory. Finally, to analyze how public sector actors are influencing MaaS developments (RQ3), this thesis combines an analytical framework from the literature on sustainability transitions (the Transition Management Framework) with the classification of hands-on and hands-off governance activities often used in the literature on collaborative innovation. The latter literature was considered appropriate since MaaS developments demand adjustments from actors spanning over at least public and private sectors and are thus dependent on inter-sectorial coordination.

CHAPTER 4
Research Design

To provide insight into the foundations of the overall research approach, this chapter first explains the structure of the doctoral research project and the epistemological assumptions that informed the methodological choice. An overview of the methodology is provided thereafter followed by descriptions of the five included empirical studies. Lastly, the cross-study analysis process is outlined.

4.1 Preconditions and Assumptions

This thesis departs from a post-positivist perspective of knowledge: an objective reality exists but can only be known imperfectly. Rather, human interpretations of the empirical world are conjectural and influenced by personal factors, cultural traditions, social norms and the historical development of knowledge (cf. constructivism). Science therefore operates on a continuum stretching from the empirical environment on the one hand to non-empirical theories on the other (cf. Scott, 2014). The thesis is more based on empirical observations than on theoretical activity; theories are treated as instruments for solving practical problems, and their usefulness is used as the criteria of their merits (cf. pragmatism). Drawing on the notion that actors' activities are bounded by what they perceive and consider (cf. Strömberg, 2015), the thesis is moreover mainly concerned with constructed meanings of MaaS developments. These have predominantly been investigated through qualitative data. Still, the data has been interpreted vis-à-vis a belief in an objective reality.

This type of pragmatic research approach entails that the researcher determines what theoretical and methodological choices are appropriate based on his/her understanding of the research objectives. Consequently, the research should be interpreted considering the context in which it was produced. The thesis was conducted via an industrial doctoral student position at PTA-VG[1]. This position has implied a dual role as both an academic scholar researching MaaS developments and a public servant providing regional politicians with advice on policy decisions (e.g. about MaaS strategies and funding of MaaS-related projects). The work at PTA-VG has moreover entailed firsthand involvement in MaaS developments in a variety of roles, for instance as a member of PTA-VG's MaaS project group, as a co-author of the Swedish roadmap for MaaS developments (KOMPIS, 2017), and as a steering group member for MaaS-related research and development projects (e.g. Hult et al., 2018).

As discussed in Smith (2017), the researcher's involvement in the studied system is associated with ethical risks. It may be difficult for research subjects (e.g. interviewees) to comprehend multifaceted roles, and participatory research designs might lead to researchers, consciously or unconsciously, interpreting and describing collaborators and employers in a favorable light (cf. Duineveld et al., 2007). To mitigate these risks, reflection on researcher bias and influence was included as a recurring element in the research process. The dual role and the research objectives have also been described as transparently and clearly as possible in both conversations with research subjects and in research outputs. The parallel involvement and analytical distance that the work format has entailed can moreover support attentiveness to the existence of multiple perspectives (including personal viewpoints). Participatory research designs may therefore leave researchers in a better position to make ethically sound decisions in relation to the research project, compared to if they solely observed (Smith, 2017).

4.2 Methodology

The number of MaaS pilots and the body of MaaS-related academic literature are both growing rapidly. Still, MaaS is a novel and not well-understood service concept. Accordingly, the research approach has been largely *exploratory* (cf. Stebbins, 2001). To accommodate this approach, the research design was purposively made flexible. The initial project plan stipulated that the activities of PTA-VG would be used as empirical studies for examining the development, diffusion, and use of MaaS. Yet, it also noted that given the inherent uncertainty regarding the success and continuation of these initiatives, other ongoing and future initiatives may be studied as well. As it turned out, the MaaS developments in Västra Götaland were not as quick and straightforward as PTA-VG had hoped. However, MaaS developments have been convoluted and slow-moving in general, not only in Västra Götaland, thus not providing the anticipated opportunities to study the use phase as initially intended. To leverage the unique research opportunities of this project (i.e. the potential of developing a rich understanding of PTA-VG and its activities), it was decided to (mostly) follow the progress in Västra Götaland. The research design was therefore revised step-by-step to focus more on the two earlier MaaS innovation phases (development and diffusion) and less on the latter phase (use). Additionally, to deepen the understanding of potential pathways for MaaS developments, and how MaaS developments are influenced by context-specific institutional factors, innovation processes in other contexts were studied as well. More specifically, the thesis project encompasses five empirical studies of MaaS development and diffusion: three situated in Sweden and involving PTA-VG; one in Finland; and one in New South Wales, Australia (these are motivated and outlined in Section 4.3).

Accordingly, the research design can be described as a *multiple-case study*. Multiple-case study design refers to research in which several bounded cases (i.e. separate entities in terms of time, place, or some other boundary) are studied and compared (cf. Yin, 2018). Among other things, this allows for the identification of how the individual cases may be

affected by different institutional environments and the specific institutional conditions under which the findings may occur (Mills et al., 2010). Multiple-case study design is therefore considered an appropriate tactic for exploring new phenomena in depth (e.g. Baxter & Jack, 2008; Eisenhardt, 1989).

To accommodate the exploratory approach, data collection and analysis strategies were inspired by grounded theory (cf. Charmaz, 2006)[2]. In particular, the open and flexible data collection techniques and the inductive analysis procedures proposed by grounded theory scholars were adopted. The method of inquiry has primarily been *qualitative* since the research was mostly focused on understanding constructed meanings of MaaS developments. Accordingly, beyond one questionnaire study and some statistics on the use of a MaaS service, the primary data used in the thesis has been collected through semi-structured interviews and document studies. These are common techniques in qualitative studies that are regarded as appropriate when the research questions deal with perceptions, experiences, and understandings, such as in this doctoral research project (cf. Creswell, 2009).

As discussed in Section 4.1, the research format has also entailed active participation in MaaS developments in Västra Götaland in particular, and in Sweden in general. This involvement has for example included more than 250 formal meetings with representatives for actors involved in Swedish MaaS developments (the informal meetings are uncountable). These meetings have been systematically documented through detailed meeting notes. Thus, the methodological approach has also been *participatory*. Participatory methods are suitable for exploring local knowledge and perceptions; a key strength is that they typically make the researchers visible and the research intents transparent (Cornwall & Jewkes, 1995). Still, participatory methods are also questioned due to a perceived lack of impartiality and bias (cf. McKay, 2001). The knowledge derived from the observations has therefore not been used as primary data for the analysis in this thesis. Still it has provided a deep understanding of different perspectives on MaaS developments. This has guided the search when selecting studies and collecting primary data and has helped the evaluation of the quality of the undertaken research.

It has been argued that "the best way to boost research quality is to discuss it often and freely" (Winchester, 2018, p. 281). The papers appended to the thesis (and early versions of this manuscript) have been presented at more than 50 seminars, workshops, and conferences. The research has also been discussed in countless informal meetings with public and private practitioners, politicians, and fellow researchers. These feedback mechanisms have benefited the *conformability* and *dependability* of the research by providing opportunities for both fellow scholars and actors involved in MaaS developments to challenge the process and the findings (cf. Lincoln & Guba, 1985). Due to the participatory element of the methodology, and the related potential bias (cf. Smith, 2017), the feedback mechanisms were seen as particularly important features. To achieve high *credibility*, the research was designed to give sufficient time to understand

the culture and social setting of MaaS developments (especially in Sweden), as well as to make sure to collect data from all relevant sources, i.e. all types of actors involved in MaaS developments in this case (cf. Lincoln & Guba, 1985). Finally, the detailed accounts of the empirical observations make it possible for readers to make their own judgments on the extent to which findings and implications are *transferable* to other cases of MaaS developments or not (cf. ibid.).

4.3 Empirical Studies

The findings in this thesis are built upon five empirical studies that are presented next, including what MaaS developments were studied, the aims of the empirical studies, and how the research was conducted. A summary of the empirical studies is provided in Table 1 (on pages 38-39), while the studies' roles in this thesis are illustrated in Figure 5.

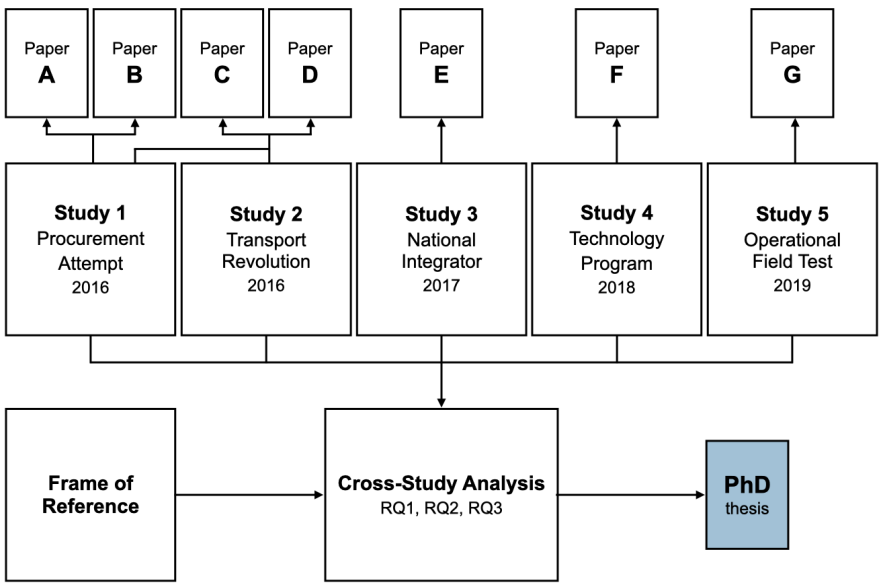

Figure 5. The roles of the empirical studies in this thesis

The three empirical studies situated in Sweden were primarily selected based on their availability; they represent the major processes in which PTA-VG took part from 2016 to 2019. Nonetheless, since the first comprehensive MaaS pilot took place in Västra Götaland, and since PTA-VG is one of the first PTAs to take concrete steps towards MaaS, these studies can be interpreted as trying to break new ground. Ground-breaking

cases are considered as appropriate for exploratory research (cf. Flyvbjerg, 2006). Guided by the analytical levels in the IRIMS framework, these three studies were designed to encompass the perspectives of all the actors that had taken active roles in the MaaS developments in Sweden thus far, including strategic and operational actors at national, regional, and local scales as well as users. The empirical study situated in Finland was selected since it comprised comprehensive MaaS developments; Finland has been widely regarded as a MaaS frontrunner (e.g. Kanger & Kivimaa, 2019). Additionally, MaaS developments in Finland have engaged a distinct set of actors and seem to have followed a different trajectory than the Swedish developments, at least initially. Thus, the Finnish case was considered to offer interesting contrasts to the studies in Sweden, and thereby potentially improve the representativeness of the thesis' findings (cf. Seawright & Gerring, 2008). The fifth empirical study, situated in New South Wales, Australia, was also mostly selected due to offering contrasts to MaaS developments in Sweden. Socio-political features such as the Anglo-Saxon heritage, the large population of Sydney, and that one agency is responsible for both public transport and much of the transport regulation sets New South Wales apart from Sweden (and Finland). This was thought to provide opportunities to learn about contextual impacts on MaaS developments. Furthermore, when Study 5 was initiated, the state government had recently communicated a plan of commencing five MaaS pilots, thus making MaaS a topical matter in New South Wales.

4.3.1 Study 1 – Procurement Attempt (Västra Götaland, Sweden)

Background: In April 2016, PTA-VG initiated a procurement process by posting an open invitation to a so-called request for information process (Västtrafik, 2016). The invitation detailed that PTA-VG was planning to carry out a procurement whereby a supplier would offer a MaaS service for Västra Götaland. An open start-up meeting for the procurement process was held in May 2016. Following the start-up meeting, PTA-VG held individual meetings with representatives from the 30 actors that had requested to meet (i.e. potential bidders). During these meetings, the potential bidders typically first presented their ideas whereby PTA-VG asked questions, guided by a list of topics of special interest. However, the meetings oftentimes ended up in open discussions. The potential bidders were also asked to provide written answers to the posted questions after the individual meetings.

Guided by the insights from the meetings and the written responses, PTA-VG put together mock procurement terms and communicated these to the potential bidders. This received overwhelmingly negative feedback. In short, the potential bidders did not see a viable business case since PTA-VG did not plan to share the business risk but still placed high demands on the comprehensiveness of the delivered MaaS service. The feedback indicated that PTA-VG and the potential bidders had vastly different viewpoints, and that the procurement process was unlikely to yield the desired results. Hence, the procurement process was cancelled in early 2017.

Aim: The aim of Study 1 was broadly to understand why the procurement process was unsuccessful, and if its problems were linked to diverging perspectives on MaaS. The study therefore explored the involved actors' experiences in relation to MaaS, visions and expectations for MaaS developments, and perceptions of the procurement process.

Method: In parallel to the procurement process, the study set out to acquire a holistic understanding of the involved actors' perceptions of MaaS and of the ongoing procurement process. Data was collected and analyzed in several ways. To begin with, the start-up meeting and the individual meetings with potential bidders were observed through active participation (cf. Spradley, 1980). The topics of discussion were documented in field notes. This data was analyzed in three steps: the field notes were read and summarized, recurrent themes were recorded and inductively clustered, and the identified themes were refined through comparisons with the appointed secretary's notes and via discussions with the other members of PTA-VG's project group.

Shortly after the individual meetings, but prior to the decision to cancel the procurement process, 19 semi-structured interviews were also conducted. To embrace different perspectives on the procurement process, interviewees were purposefully sampled (cf. Tongco, 2007) from the group of potential bidders to represent all types of roles in the emerging MaaS value chain (see Figure 2). In a similar process, interviewees from PTA-VG were selected from different organizational units. The interviews, which were recorded and transcribed, followed an adaptable and flexible interview guide based on the list of identified themes. Following the recommended analysis process in Charmaz (2006), the interview transcripts were first coded inductively and memos[3] were developed to summarize the core of the largest clusters of codes. A review of the memos showed that a sizable portion of them addressed notions of institutional barriers affecting MaaS developments. Thus, a second and more thorough analysis of the quotations, focusing on perceptions of barriers, was performed. This resulted in refined codes that described perceptions of barriers (including whether public, private, or public and private sector interviewees had mentioned them). As a last exercise, the barriers were categorized based on a framework of levels of analysis adopted from Bogers et al. (2017).

4.3.2 Study 2 – Transport Revolution (Finland)

Background: In Finland, MaaS was first proposed by private entrepreneurs around 2012. The Finnish Ministry of Transport and Communications (Finnish: *Likenne- ja viestintäministeriö*, LVM) quickly picked up the concept, and started using it as a communicative tool for explaining and promoting its envisaged reform of the transport sector. As a consequence, from the very start, Finnish MaaS developments have been tightly coupled with an ongoing deregulation of the transport sector (cf. Finlex, 2017:320). Furthermore, several other public sector actors in Finland started promoting MaaS developments at an early stage, for instance by funding MaaS experiments.

By the end of 2016, several MaaS services had been, or were being, piloted in Finland. Moreover, MaaS Global Oy (the company behind Whim) had received a considerable amount of global media attention, had raised significant amounts of venture capital funding, and had managed to strike a deal with the regional PTA for Greater Helsinki (Finnish: *Helsingin seudun liikenne*, HSL) that allowed them to include public transport tickets in its offering. Moreover, the parliament was about to vote on the enactment of the first phase of a bill called the Transport Code, which was a cornerstone in the envisioned reform of transport. This first phase intended to pave the way for MaaS developments by harmonizing regulation across service systems and by deregulating the taxi market. It also forced all mobility service providers in Finland (public and private), to provide third-party actors (such as external MaaS Operators) access to their data and tickets, and to allow them to purchase and resell single trip tickets (and/or corresponding products). Due to these developments, Helsinki was (at the time) seen as the place where MaaS was (really) happening.

Aim: Study 2 embarked on an exploration of commonalities and differences across MaaS developments in Finland and Sweden. The developments seemed to be following different trajectories, and the study set out to comprehend if and why that was. Thus, it aimed at identifying what actors had been involved thus far, and how they perceived the past and ongoing developments.

Method: In December 2016, ten individual and two group interviews were performed with actors involved in Finnish MaaS developments. A semi-structured interview guide was used to organize the interviews around the three institutional levels in the IRIMS framework: macro, meso, and micro (see Section 3.2). In addition to the interviews, public sector actors' websites and databases were reviewed to collect the official documents that Finnish and Swedish public sector actors had published in relation to MaaS until that point.

The transcriptions of the interviews were first coded and clustered inductively. Then, two analyses were performed in parallel, both focusing on contrasting the MaaS developments in Finland to their equivalents in Sweden. In the analysis reported in Paper C, the IRIMS framework was applied to understand how institutional arrangements affect MaaS developments, while the analysis reported in Paper D focused on identifying what types of policy instruments public sector actors have utilized to govern MaaS developments. In the latter analysis, identified policy instruments were classified in terms of formal/informal, and organized using four policy instrument categories adopted from Hultén (2012): strategy management, collaboration, financing, and regulation. The identified policy instruments were also analyzed in relation to four archetypical public sector roles in relation to governing experiments developed by Kronsell and Mukhtar-Landgren (2018): promoting, partnering, enabling, and taking a non-role (these roles are further described in Section 8.2).

4.3.3 Study 3 – National Integrator (Sweden)

Background: Following a year-long pre-study, Samtrafiken AB (a development company jointly owned by 37 public and private actors in the Swedish mobility service industry) launched a project called the Swedish Mobility Program in January 2017 (Samtrafiken, 2017). In short, the project aimed to develop a plan for how Samtrafiken AB could become a MaaS Integrator for the Swedish market. Having realized that its procurement process would be unsuccessful, PTA-VG was an outspoken proponent of this initiative. Hence, PTA-VG co-funded the project and set out to be a leading actor in its implementation (Västtrafik, 2017; VGR, 2017).

The project hosted extensive dialogues with mobility service providers, prospective MaaS Operators, and suppliers of technical platforms. These dialogues were mostly focused on understanding what functions the MaaS Integrator role should encompass to best facilitate MaaS developments. The project moreover carried out a feasibility study for a technical integration platform, identified potential suppliers, and investigated legal aspects. Based on the outcome of these activities, Samtrafiken AB proposed that its board of directors establish a new business unit designated *Mobilitetstorget* (approximately the Mobility Square in Swedish). This unit would facilitate MaaS developments through technical, business, and process facilitation activities.

However, the board judged that the benefits of Mobilitetstorget would not be enough to motivate the required direct and indirect investments. The board stressed that Mobilitetstorget did not have enough support from mobility service providers and that it was uncertain whether prospective MaaS Operators would be interested in Mobilitetstorget's technical and business services. Thus, the board rejected the plan and commissioned Samtrafiken AB to only proceed with the suggested process facilitation work.

Aim: To improve the understanding of how MaaS Integrators might be appreciated by actors in the MaaS value chain, Study 3 sought to uncover different viewpoints on Mobilitetstorget. It aimed to understand why the Mobilitetstorget plan did not gather support, if perspectives diverged across actor types, and whether the lack of support might be related to expectations on how MaaS would influence personal mobility systems.

Method: Shortly after the board's decision to reject Mobilitetstorget, a convergent mixed-method case study was initiated (cf. Creswell, 2009). Qualitative data was collected through 27 semi-structured interviews with a purposive sample chosen to represent the groups of mobility service providers and prospective MaaS Operators in Sweden. The interviews focused on experiences of and perspectives on MaaS developments in general and the Swedish Mobility Program in particular. Additionally, quantitative data was collected through a questionnaire to the same sample. In the questionnaire, the respondents were asked to react to a set of Likert-scale statements (cf. Likert, 1932) that primarily regarded potential barriers to and impacts of MaaS and Mobilitetstorget, respectively.

Following the recommended iterative process in Creswell and Clark (2017), the interview transcripts were first analyzed and coded. A cross-tabulation matrix of code groups and interviewee subgroups was developed to reveal consistent as well as inconsistent perspectives on MaaS, and the code themes related to Mobilitetstorget were further interpreted using mind-maps and memo-writing techniques. Thereafter, a non-parametric analysis of the questionnaire data was performed in two steps: the responses to the Likert-scale statements were visualized as box plots, and a Kruskal-Wallis test (cf. Kruskal & Wallis, 1952) was performed to identify if there existed differences between interviewee subgroups' responses. This enabled triangulation of the findings from the qualitative analysis.

4.3.4 Study 4 – Technology Program (New South Wales, Australia)

Background: Beyond research, Australia has not witnessed many MaaS-related activities until relatively recently (compared to e.g. Sweden and Finland). However, the statutory authority that manages the mobility services in the state of New South Wales, Transport for New South Wales (TfNSW), has become increasingly interested in MaaS. In 2016, TfNSW released a transport strategy (TfNSW, 2016a). Recognizing that services are increasingly being delivered by a diverse group of external actors, the strategy identified "moving to 'Mobility as a Service' (MaaS) and beyond" (ibid., p. 15) as a chief tactic for unlocking seamless, interactive, and personalized transport experiences.

The transport strategy was complemented with a roadmap for technology developments, which pinpointed vital technology projects such as developing a statewide, single-account, mode-agnostic payment technology, and enabling other mobility service providers to integrate into it (TfNSW, 2016b). To support and fast track the initiatives pinpointed in the roadmap, TfNSW launched a program for collaboration with the private sector on digital innovation, entitled the Digital Accelerator Program (TfNSW, 2018c). As part of this program, TfNSW hosts innovation challenges. The first one, called the MaaS Challenge, departed from the following problem statement: "how would you give customers optimal door-to-door mobility service options and seamless combinations for their situation, including the first and last mile" (TfNSW, 2018a, p. 4)? Undertaken in 2018, the challenge produced five MaaS-related pilots to be conducted in 2019-2020 (TfNSW, 2018b).

Aim: It was presumed that insights to the dynamics of MaaS developments in a dissimilar socio-political and regulatory context (compared to the Nordic context) could inform the research on MaaS developments in Sweden and Finland. Study 4 therefore set out to study past and present MaaS activities in New South Wales, and TfNSW's MaaS-related governance activities.

Method: In late 2018, eleven individual interviews and eight group interviews were performed. The interview sample, which was selected based on a snowball sampling technique (cf. Marshall, 1996), covered 33 people in total: 14 employed by TfNSW,

seven representing other Australian public sector actors, ten active in the private sector, one from academia, and one working for a non-profit organization. In addition to the interview study, official documents of TfNSW, such as strategies, roadmaps, and press releases related to MaaS were also collected and read. These documents provided an overview of TfNSW's MaaS governance activities, which was used to triangulate the interview material. To analyze the interview material, the interviews were transcribed, and analyzed inductively. This analysis revealed which of TfNSW's activities that the interviewees perceived as influential for ongoing and future MaaS developments in New South Wales. The identified activities were categorized using an analytical framework inspired by the Transition Management Framework and the categorization of hands-on and hands-off activities from the collaborative innovation literature (see Section 3.3).

4.3.5 Study 5 – Operational Field Test (Gothenburg, Sweden)

Background: Following the close of the Swedish Mobility Program project, PTA-VG had to revise its MaaS strategy once again. The revised strategy focused on opening for third-party resale of the public transport offering (VGR, 2018)[4], and this choice was based on the notion that more practical experience is needed to identify what role(s) MaaS can play in sustainable personal mobility systems as well as what roles PTAs should have in delivering MaaS. It was also motivated by the broadly accepted assessment that laws and regulations hinder PTAs from adopting the MaaS Operator role in Sweden (see Section 6.2), and that the private sector can develop and deploy a range of MaaS services faster than the public sector can.

PTA-VG identified five main tasks that it had to undertake to be able to open for third-party resale: harmonizing the technical interfaces for data and tickets; developing processes and systems, such as for on-boarding, invoicing, and monitoring; establishing an organizational unit for the new type of sales channel; and drafting a generic third-party resale contract and double-checking it with legal advisors. Additionally, there were a lot of administrative and internal anchoring duties to perform as well. To test and refine the developed components, PTA-VG set up a three-phased roadmap: an initial pilot to develop and refine technical interfaces; a range of market pilots to test technology, processes, and systems; and continuous third-party resale (VGR, 2019b). One of the (ongoing) market pilots in the second phase was dubbed the Viva pilot.

Viva is a newly built housing cooperative (Swedish: *bostadsrättsförening*) in central Gothenburg, Sweden, which consists of 132 apartments distributed across six buildings. The housing cooperative is meant to demonstrate how the ecological footprint of housing and living can be reduced. Among other things, there is no residential car parking for the tenants. Instead, Viva features extensive, dedicated bicycle infrastructure including a large-scale garage with a ramp and an elevator as well as charging facilities and a room with repair stands and tools. The tenants also have exclusive access to a

MaaS service, called EC2B. Its app enables them to book and pay for a pool of shared vehicles (mostly e-bikes), regional public transport, and car sharing. Beyond booking and payment functionalities, the app features payment history and occasional discounts for public transport and can be used to access information and customer support (i.e. a level two service according to Sochor et al., 2018a). Furthermore, the company that operates EC2B (EC2B AB) invited the tenants to workshops when designing the service and hosted several meet-ups and coaching sessions after its launch. At these, tenants could talk about their travelling and try out the app and the included mobility services.

Aim: The Viva pilot provided the first opportunity, within the scope of this doctoral research project, to study the MaaS diffusion phase. The main interest of Study 5 was thus to engage with MaaS users and to understand their perspectives on MaaS. In particular, the study aimed to understand who was interested in MaaS (or not) and how they wanted to use MaaS. It also strived to explore what factors drove and hindered the Viva tenants from adopting the trialed MaaS service.

Method: Data collection was initiated a few weeks after the EC2B service was launched. Data on the tenants' adoption processes was primarily collected through two waves of household interviews (i.e. interviews with one or several members of the household). In total, 26 households were interviewed initially. Follow-up interviews were conducted with 14 of these households roughly two months after the initial interviews. Additionally, the interview data was complemented with three types of supplementary data: anonymized notes from individual coaching sessions with the Viva tenants, booking and sales statistics, and participatory observation of introduction meet-ups. In the analysis phase, the interview recordings were transcribed, and coded thematically. This process encompassed familiarizing oneself with the interview data, generating initial codes, and searching for, reviewing, naming, and summarizing themes (cf. Braun & Clarke, 2006). This output served as the primary data for the analysis and was triangulated with the other data types.

4.4 Cross-Study Analysis

A cross-study analysis (cf. Byrne, 2009) was performed to address the three research questions. This analysis followed a case-oriented methodology (cf. Khan & VanWynsberghe, 2008), meaning that it was performed in a more holistic sense than commonly done in conventional reductionistic approaches to producing research syntheses (cf. Yin, 2018). It strived towards preserving the essence of each empirical study when addressing the research questions, and learning from their differences as well as from their similarities (cf. Stake, 2013). Therefore, observations related to the three research questions were first separately identified within each study, prior to searching for replications across the studies. In practice, this entailed five fundamental steps in the cross-study analysis process, as illustrated in Figure 6.

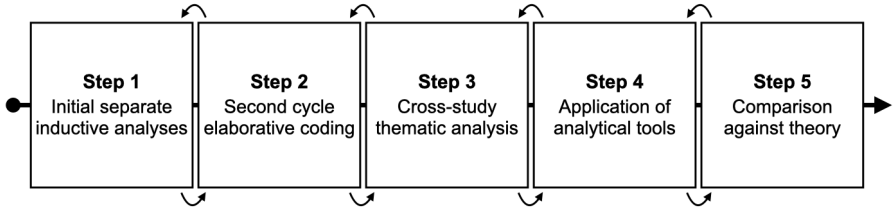

Figure 6. Cross-study analysis process

In step one, each of the five empirical studies were first analyzed inductively (bottom-up), and then compared against existing theory and evidence. These analysis processes are described in Section 4.3, and the appended papers represent the output from this step. The analytical frameworks deemed most appropriate at the time were applied. Beyond MaaS literature, the analysis of Study 1 was primarily grounded in open innovation concepts (cf. Chesbrough, 2003; 2006). Centering on practices of accessing, harnessing, and absorbing flows of knowledge across organizational boundaries, the open innovation literature has many commonalities with the literature on collaboration innovation but has previously mostly been applied to study the innovation strategies of high-technology firms. Institutional theories as well as the transition management and the IRIMS frameworks were employed in the analysis of Study 2, while the analysis of Study 3 drew on the Transition Management Framework as well as research on open innovation intermediaries (cf. Hallerstede, 2013) and two-sided markets (cf. Eisenmann et al., 2006). The analysis of Study 4 combined insights from sustainability transitions studies and collaborative innovation, and finally, the analysis of Study 5 utilized Strömberg's (2015) amended version of Roger's (1995) innovation-decision process.

The three research questions were introduced in the second step of the cross-study analysis. In a second cycle coding processes, the material relevant for answering the research questions was selected and analyzed anew. This entailed that, for each of the empirical studies, the appended papers were reviewed alongside working material (e.g. tentative propositions, identified code groups, and quotations) and raw data (e.g. interview transcripts and policy documents). The applied codes were based on constructs and findings from first step of the cross-study analysis. Hence, the coding technique can be described as top-down and elaborative; an analysis approach which has been identified as appropriate for qualitative-oriented studies that aim to further develop previous research (cf. Saldaña, 2015).

In the third step of the cross-study analysis, three mind-maps (one per research question) were developed to communicate and organize the output from step two. The mind-maps illustrated dominating code groups. They moreover highlighted links between codes (if the codes were associated with each other and if their contents were contradictory) as well as similarities and differences across the empirical studies.

The frame of reference described in Chapter 3 informed the analytical thinking in both steps two and three but was applied more explicitly in the fourth step of the cross-study analysis, which aimed at integrating the findings from the empirical studies. For research question one, the conceptualization of MaaS developments as potentially contributing to personal mobility system transitions was used to search for and describe anticipated impacts of MaaS. Thus, identified code groups were organized according to if they primarily related to service systems (public transport, private cars, other mobility services, and active mobility), alignments between service regimes, or wider socio-technical impacts. For research question two, the institutional factors were classified according to the IRIMS framework, i.e. as drivers or barriers at the macro, meso, or micro level. For research question three, governance approaches were categorized based on the framework for MaaS governance activities described in Section 3.3; they were recognized as hands-on or hands-off (or both) and as targeting the strategic, tactical, operational, or reflexive levels of governance. Based on these exercises, a memo-writing technique was used to develop tentative findings. Following several iterations between the tentative findings and the data from the empirical studies, final results were summarized for each research question. Chapters 5, 6, and 7 describe this output: one chapter per research question.

Finally, in the fifth step of the cross-study analysis, literature on MaaS as well as the literature utilized in the frame of reference (Chapter 3) was reviewed once again to compare the results in step four, for each of the research questions, against existing theory and empirical evidence. This helped refine and position the results and to understand how they contribute to the emerging MaaS literature and to sustainability transitions studies. The insights from this fifth and final step in the cross-study analysis are described and discussed in Chapters 8 and 9.

Table 1. Overview of the empirical studies

Study	Data & analysis	Main findings (reported in the appended papers)
Study 1 – Procurement Attempt	Data Semi-structured interviews (n=19), document analysis, and participatory observation. Analysis Inductive coding and clustering, focused coding, memo-writing, and categorization of institutional barriers.	The analysis identified that the public or the private sector, or both, can adopt the MaaS Operator and MaaS Integrator roles. Thus, there are three development scenarios for MaaS: market-driven, public controlled, and public-private (see Paper A). The analysis also revealed that multiple institutional barriers are perceived to hamper MaaS developments, especially related to public-private collaborations. Although some barriers were consistently pinpointed by all types of actors, the understanding of barriers diverged; both public and private actors were primarily aware of, and regarded, the types of barriers that directly affected their own line of work (see Paper B).
Study 2 – Transport Revolution	Data Semi-structured interviews (n=12), and a policy document review. Analysis Inductive coding and clustering, and categorization of institutional factors and of applied policy instruments.	The analysis found that the MaaS developments in Sweden and Finland were following dissimilar trajectories, with different end-goals, strategies, and types of actors in leading roles. While MaaS was frequently motivated as possibly promoting sustainability in Sweden, MaaS' potential capacity to tear down transport silos and streamline the public sector's role in transport was more in focus in Finland (see Paper C). The analysis also found that public sector actors were applying a wide range of policy instruments to govern the development of MaaS. While the regional government was most active in Sweden, the national government had the leading role in Finland (see Paper D).
Study 3 – National Integrator	Data Semi-structured interviews (n=27), questionnaires (n=27), document analysis, and participatory observation. Analysis Inductive coding and clustering, mind-maps, memo-writing, box plots, and a Kruskal-Wallis test.	The analysis identified many institutional barriers regarded to hamper MaaS developments. It also revealed that different actors faced different challenges. For example, public transport authorities typically struggled with internal prioritization while private mobility service providers stressed issues related to user relations and branding more frequently. Moreover, the analysis revealed that the proposed national MaaS Integrator was anticipated to instigate policy changes, lower entry barriers, facilitate collaboration, propel operative actions, manage the innovation trajectory, and streamline investments, but also to inhibit service quality, add unnecessary costs, and impair commercial potential (see Paper E).

Study	Data & analysis	Main findings (reported in the appended papers)
Study 4 – Technology Program	Data Semi-structured interviews (n=19), and a policy document review. Analysis Inductive coding and clustering, and categorization of governance activities.	The analysis identified multiple institutional drivers and barriers. Some of these were clearly contextual, such as a technology enthusiastic state government (driver), a powerful state authority with a large action space (driver), and a spread-out car-centric society (barrier). The analysis also identified that TfNSW regarded MaaS as a key instrument for improving the experience of using public transport and improving the efficiency of the personal mobility system. To promote MaaS, TfNSW was applying a range of hands-on and hands-off governance activities at strategic, tactical, operational, and reflexive levels (see Paper F).
Study 5 – Operational Field Test	Data Semi-structured interviews (n=40), sales and booking statistics, and participatory observation. Analysis Inductive coding and clustering, categorization of drivers and barriers, and basic statistics and diagrams.	The analysis found that adopters were younger, tech-savvier, and less inclined to own cars than non-adopters. It also showed that the MaaS service was used for a wide range of reasons, and had replaced private car trips as well as public transport and traditional bicycling. Drivers for adopting the MaaS service included ambitions to drive less, curiosity, and to save time and hassle, while barriers included competing habits and a tedious on-boarding process (see Paper G). Technical infrastructures and an organizational unit, routines, and contracts that support third-party retailers were moreover identified as MaaS development enablers, as well as clarity regarding short-term goals and the long-term strategy.

1. The doctoral research project is a result of collaboration between the Division for Public Transport and Infrastructure at Region Västra Götaland (department: Regional Development), K2 – The Swedish Knowledge Centre for Public Transport, and the division Design and Human Factors at Chalmers University of Technology (department: Industrial and Materials Science). The author has moreover been on temporary leave from RISE – Research Institutes of Sweden during the doctoral project period and since December 2018 holds an honorary research associate position at the Institute of Transport and Logistics Studies at University of Sydney.
2. In short, grounded theory pinpoints empirical observations as the only source of knowledge, and facilitates rigorous qualitative research by providing a set of data collection and analysis strategies that aim at discovering research subjects' experiences and perceptions (cf. Charmaz, 2006).
3. Memos present interim hypotheses about connections between code groups and begin to integrate these connections with clusters of other code groups to generate findings and conclusions (Holton & Walsh, 2016). Memo-writing has therefore been described as "the pivotal intermediate step between data collection and writing papers" (Charmaz, 2006, p. 72).
4. Cf. the *making the offering available* scenario detailed in Chapter 2.

PART 3 FINDINGS

CHAPTER 5
Anticipated Effects

This chapter addresses RQ1: (a) What effects do actors involved in MaaS developments foresee that MaaS will have on personal mobility, and (b) how have these expectations influenced MaaS developments? To provide a backdrop for the analysis, three basic rationales present in the five empirical studies are first introduced. The chapter then proceeds to describe how MaaS is anticipated to influence service systems and the alignments between service regimes prior to providing a summarized answer to the questions.

5.1 Basic Rationales

The grey literature on MaaS is full of claims regarding a speedy and widespread diffusion of MaaS and how this will benefit users and society (e.g. Ertico, 2018; MaaS Alliance, 2017). The introduction of MaaS is predicted to give rise to a new mobility sector, that beyond providing better integrated services across all types of personal mobility will also improve the links between personal mobility systems and other social services, such as education, jobs, and health care (e.g. Atkins, 2016). In short, MaaS is said to offer "the potential to address many of the transport challenges facing society" (Catapult, 2016, p. 6) and is thus argued to "be a good thing for most travelers as well as the planet" (Fritz, 2014, p. 4).

In contrast, the 125 actors involved in MaaS developments interviewed for this thesis (hereafter referred to as the respondents) acknowledged that the effects of MaaS developments are largely uncertain. It was frequently stated that MaaS will harness technological opportunities but that the effects beyond that are unclear. Several respondents reasoned, for example, that technological advances are difficult to plan, and thus, one can only speculate on how MaaS will affect personal mobility prior to witnessing its evolution. Yet, three distinctive, basic rationales regarding the effects of MaaS emerged from the cross-study analysis: *belief*, *skepticism*, and *opposition*.

MaaS believers were confident that MaaS will be realized, revolutionize personal mobility systems, and bring benefits for both users and society. The introduction of MaaS will, according to their line of thinking, lead to a richer and more user-centric palette of mobility services. Users will be able to access this palette through multiple competing MaaS offerings (Study 2), and thereby get better opportunities to plan their travelling and to compare different service offerings (Study 4). This will contribute to seamless, personalized, and interactive door-to-door experiences (Study 4). It may also simplify travelling, especially inter-modally (Study 1), lower entry barriers to try out new mobility services, and unlock new ways of travelling (Study 5). MaaS may therefore, when realized, offer users a higher level of mobility flexibility (often referred to as *mobility freedom*) compared to private car ownership (Study 2).

Due to this enhanced flexibility, MaaS developments were believed to have the capacity to compete with car ownership and reduce car dependency and thereby contribute to more sustainable personal mobility systems (all studies). This notion materialized in many MaaS-related policy documents across the studies. For example, impact targets for MaaS developments included reduced climate impact, improved opportunities to travel with mobility services, less congestion and space allocated for parking, more attractive urban environments, and better utilization of street environments (Studies 1 and 4). In terms of equity, MaaS was believed to extend the reach of mobility services by bridging the gap between traditional public transport and first-and-last mile services (Study 4) and by assisting the evolution of a greater collection of mobility services in rural areas (Study 1). If so, MaaS can improve the accessibility within and between regions (Study 1), reduce transport exclusion (Study 1), and empower groups that currently lack car access (Study 5). Furthermore, some respondents held that the introduction of MaaS will have positive public health effects due to prompting more walking and cycling (Studies 4 and 5).

Beyond environmental and social benefits, MaaS believers frequently contended that MaaS will transform personal mobility systems from public cost burdens to economic growth opportunities (Study 2). MaaS' introduction could help unlock the full value of transport networks and thus reduce future needs for transport infrastructure investments (Study 4) and streamline public spending on personal mobility by replacing inefficient subsidized services (Study 2). It could also open opportunities for new types of mobility services (Study 1) and for private entrepreneurship (Study 2), which in turn can increase private investments in mobility services (Study 2) and create a vibrant open marketplace (Study 4), thus contributing to a productive economy by creating economic growth, new local business, jobs, and export opportunities (Studies 2 and 4). The vibrant marketplace for mobility services may also enhance the reputation of involved parties, while regions and countries might become increasingly characterized as innovative (Studies 1 and 2).

MaaS skeptics held that MaaS developments' effects on personal mobility systems will be insignificant. Two propositions typically underpinned this belief. Firstly, several respondents thought that the conditions for MaaS are not in place. For example, many

mobility services are still not digitalized, and their data interfaces are not yet standardized. This makes it difficult to integrate them into MaaS services (Study 3). The MaaS skeptics also felt that the scalability of MaaS is limited due to personal mobility being organized differently across regions (Studies 1 and 2). Moreover, the whole idea of MaaS is based on changed attitudes toward asset ownership, and a few respondents pointed out that this trend has just started and is yet to permeate society (Study 4). So, the MaaS skeptics argued that such institutional barriers will hinder MaaS developments, at least in the short and medium term (see Section 6.2).

Secondly, some MaaS skeptics believed MaaS will not offer any substantial benefits to users. They considered that people are increasingly used to juggling multiple mobility apps, and that emerging payment technologies, such as contactless payment systems, will make mobility-specific solutions obsolete (Study 4). If realized, MaaS would therefore be unlikely to make travelling significantly more convenient, which would impede peoples' willingness to pay for MaaS. Moreover, MaaS skeptics felt that MaaS will hardly make travelling cheaper since the concept introduces additional actors into the value chain for mobility services (Study 3). Consequently, the potential market for MaaS is limited to small niches, and thus, any possible effects of MaaS would be small-scale.

MaaS opponents regarded MaaS developments as harmful either for people (especially non-users), incumbents, or society, or all three. Using past and ongoing MaaS pilots as examples, MaaS was considered destined to become an expensive type of service (Study 3), which mostly targets people that are allowed to, have access to, and can afford to drive cars (Study 5). MaaS may therefore only become available for the technology-savvy, price-insensitive urban elite, and thus increase inequity (Study 4). Moreover, MaaS could make personal mobility systems more difficult to comprehend for people, for instance by clouding how responsibilities are distributed across operational actors (Study 2).

MaaS will most probably make traveling via mobility services easier for the market segments they target though, which can induce travel demand (Study 1) and offer better opportunities for door-to-door travelling via motorized modes, and thus have negative consequences for public health (Study 2). In particular, MaaS can make private mobility services, such as car sharing and ride sourcing, more accessible (Study 5) and thus help these mobility services compete with, and cannibalize on, traditional public transport (Study 1). Accordingly, MaaS opponents foresaw a significant risk that MaaS will support a modal shift towards less space-efficient and more environmentally harmful modes (Study 3). By tapping into the few profitable public transport routes, MaaS might moreover erode the PTAs' business models (Study 1) and thereby contribute to the decline of public transport and other subsidized types of mobility services (Study 2), which would be particularly problematic for unprofitable markets, such as rural areas.

Additionally, MaaS opponents typically anticipated that multi-national corporations will eventually obtain initially successful local start-ups (Study 2), ultimately resulting

in monopolies or oligopolies in which a few actors dominate personal mobility systems and dictate their rules (Study 2). Among other things, they felt that this could make governance more difficult for local and regional actors and reduce the financial margins for mobility service providers (Study 3). It might also reduce the level of local reinvestment of the money that people spend on personal mobility.

These three basic rationales – belief, skepticism, and opposition – represent three extreme schools of thought. The respondents existed on a continuum between them. Still, the rationales can be used to illustrate how views on MaaS can differ across actor types (strategic actors, operational actors, and users)[1] and contexts. MaaS believers were in the majority across the empirical studies and dominated the overall MaaS discourse. For instance, this rationale influenced most of the studied MaaS policy documents. Yet, respondents were more frequently proponents of MaaS in the empirical studies situated in Finland and Australia (Studies 2 and 4) compared to the respondents in Sweden. Moreover, although all types of actors were represented among MaaS believers, strategic actors and new entrants at the operational level fell into this category more frequently, compared to the other actor types. Incumbent mobility service providers more typically fell into the skeptical and/or opposition categories. A few users that had decided not to try the MaaS service in Study 5 also belonged to the MaaS skeptic category. In general, the pattern was that those actors who were more vested in the existing personal mobility regimes were less inclined to believe in the positive effects of MaaS (MaaS opponents), and those who had more practical experience of MaaS developments were more inclined to emphasize the challenges of the concept (MaaS skeptics).

5.2 Service Systems

The actors involved in the studied MaaS developments primarily brought up three types of personal mobility when discussing MaaS developments' potential impact on personal mobility systems: private car traffic, mobility services, and active mobility. The anticipated effects on the socio-technical systems surrounding these (i.e. service systems) are described in this section.

Private cars currently dominate many personal mobility systems. For example, cars account for 83% of the passenger-kilometers of inland personal mobility in the European Union (Eurostat, 2019c). As described in the previous section, MaaS believers were in majority across the five empirical studies. They frequently portrayed MaaS as a new viable alternative to car ownership, as MaaS' introduction was anticipated to reduce the perceived need to own cars. Accordingly, the car industry was often believed to be the principal loser of MaaS diffusion. In fact, several respondents pinpointed the possibility to tap into the money that people spend on private cars as one of the main drivers for the operational actors to engage in MaaS developments. As one respondent put it: "is MaaS the decline or the death of car ownership; at least it has the potential of unleashing the 80% of mobility budgets that they [mobility service providers] have not been able to tap into" (Study 2).

Essentially, a majority of the respondents (MaaS believers and not) expected that car manufacturers will lose revenue since the introduction of MaaS will imply that a larger share of mobility budgets is spent on mobility services. Several respondents saw the car industry's launching of, and investments in, mobility service ventures as responses to this threat (and opportunity). In other words, they held that MaaS developments had already started to transform the private car system. However, as emphasized by MaaS opponents and MaaS skeptics, MaaS developments may increase car use for selective groups too, since MaaS can provide them with better and easier access to cars.

Mobility services discussed during the interviews included traditional mobility services such as public transport and taxi as well as new types of services such as commercial ride sharing. MaaS was largely believed to facilitate the introduction of new types of mobility services since these services can become a part of a greater whole and possibly leverage past infrastructure investments, well-established brands, and communication channels. Furthermore, the majority of the respondents believed MaaS will promote the total use of mobility services at the expense of private car use. In contrast, it was more contested which types of mobility services MaaS will benefit.

For example, anticipations diverged regarding whether MaaS will increase (Studies 1 and 3) or decrease (Study 2) the market share of traditional public transport. The respondents who thought that public transport will decline as a result of MaaS often based this on the idea that MaaS will help other types of mobility services replace inefficient links in the public transport system and/or on a worry that MaaS will damage the possibilities to develop, operate, and govern public transport efficiently. Still, most of the respondents argued that MaaS will make it easier for more people to use public transport as the basis for their travelling, thus bringing new user segments to public transport (Study 3) and reinforcing public transport's role as the backbone of mobility services, and ultimately contributing to growth goals for public transport (Study 1). The composition of public transport may change too. Many respondents believed that MaaS will add to a shift towards more on-demand-based and less timetable-based public transport services.

Depending on the trajectory of MaaS developments, MaaS was anticipated to enlarge or reduce the scope of PTAs (Studies 1 and 2). Essentially, will the new responsibilities that MaaS brings about fall under the responsibility of PTA or not? Either way, most of the respondents were confident that MaaS will disrupt public transport systems and thus necessitate changes to PTAs' organizations, processes, and staff competencies.

Next to public transport, new types of car-based mobility services, such as transport network companies, peer-to-peer sharing, and ride sharing, were often portrayed as the main benefactors of MaaS developments (Study 1). Due to strengthening the links to public transport, respondents contended that MaaS, if realized, would improve the business models for these services, e.g. opening better opportunities for car-based mobility services to act as feeder systems to public transport. However, this growth may

come at the expense of traditional car-based mobility services, such as taxi, as well as at mobility services not included in MaaS (Study 5). As one respondent acknowledged: "while some mobility services will prosper, others will die out" (Study 2).

Active mobility was by many considered to profit from MaaS developments. This proposition was primarily based on the idea that MaaS will support car-free lifestyles and thereby facilitate a decline in car ownership and use (Studies 4 and 5). Among other things, this could reduce lock-in effects and free up road space and infrastructure investments for alternative uses. However, some worried that MaaS will replace walking and traditional cycling by providing better access to door-to-door mobility services (Study 5). Following the reasoning that services not included in MaaS may suffer from MaaS developments, some respondents also brought up the inherent risk associated with the fact that most active modes do not generate any direct revenue. Consequently, MaaS developments might not promote their use, if their lack of direct profitability is not corrected for.

5.3 Alignments

As described in Section 3.1, the ability to align service regimes (i.e. the specific institutional environments for different types of mobility services) is a cornerstone of MaaS' assumed value proposition. The analysis revealed five types of alignments within personal mobility systems, which respondents anticipated that MaaS will produce or enhance. These alignment types are explained below.

The ongoing introduction of new types of mobility services has been said to blur the line between public transport and other mobility services (e.g. TransitCenter, 2016) as well as between mobility services and private cars (e.g. CAR, 2016). The respondents often viewed MaaS developments as part of, and contributing to, these trends (Studies 1-4). MaaS was held to make mobility services more interoperable for people (Study 4), and thus make experiences of travelling multi-modally more seamless (Studies 2 and 4). From the perspective of the users, this can be understood as *cognitive alignments* between service regimes. In other words, MaaS can help users become aware of and consider the possibility to combine multiple types of mobility services.

Next, many respondents put forward the idea that MaaS will help personal mobility systems transform towards a state in which each mode increasingly focuses on the tasks for which it is best suited, and mobility services are better synchronized in time and space so that they link with and complement each other (all studies). This type of coordination can be described as *operational alignments*.

To accomplish such organizational alignments, MaaS demands increased public-private collaboration both when developing and operating mobility services (Studies 2 and 4). Whim can be used as example to illustrate this point. The launch of Whim in Helsinki was enabled by investments from an array of national and international backers and by

agreements with HSL (the PTA for Greater Helsinki) as well as with both global and local mobility service providers. MaaS Global Oy has additionally collaborated tightly with the Finnish Funding Agency for Innovation, LVM (the Finnish Ministry of Transport and Communications), the nonprofit association ITS Finland, and the City of Helsinki in the development and marketing of Whim. The operation of Whim is moreover dependent on the successful operation and coordination of public transport, car sharing, bicycle sharing, and taxi. According to the respondents, MaaS requires this type of multi-organizational setup, which in turn may enlarge inter-organizational dependencies (Studies 3 and 4), reduce public control (Study 2), make land-use planning more difficult (Study 2), and make it tougher to fine-tune mobility services (Study 3). However, the respondents also thought that MaaS collaborations will create stronger bonds between actors within and across different service systems (Study 1), and thus enhance *organizational alignments* within personal mobility systems. In other words, MaaS can help align strategies, capabilities, procedures, and rationales (etc.) across service regimes by increasing the need for inter-organizational interaction and coordination.

MaaS was also anticipated to disrupt the relationships between mobility service providers and their customers (i.e. users). Many respondents predicted that the direct contact between mobility service providers and users will decline (Studies 2 and 3). Mobility services might even become white-labeled (Study 2), and some worried that this will impair opportunities to market public transport (Study 2) and lower public control over public transport brands (Studies 1 and 3). Still, the greatest danger associated with less direct user contact was the loss of business intelligence. Most respondents agreed that MaaS will create better information on travel patterns, but MaaS might also create monopolies of knowledge for the MaaS Operators. If mobility service providers do not get access to travel data, it will downgrade their understanding of users (Studies 2 and 3) and thus their capability to fine-tune their services. However, if the mobility service providers get access to better multi-modal data, it will upgrade their planning capabilities (Studies 1 and 3) and assist the management of transport networks (Study 4). Hence, MaaS developments may provide actors across service systems with a better overview of the personal mobility system. This potential outcome can be described as *informational alignments* between service regimes.

Finally, MaaS was also foreseen to disrupt the economic side of personal mobility systems. It was frequently held that MaaS demands new types of business models that build on many actors sharing profits (see Section 6.2), implying enhanced dependencies across operational actors' finances. MaaS can also transform the structure of how mobility is subsidized and push for new ways of pricing transport (Study 2) since MaaS may improve opportunities for more flexible and dynamic use of incentives. For example, MaaS might help expand subsidies from only covering public transport to covering other shared modes or ease a shift towards subsidizing the traveler instead of the services (Study 2). If MaaS developments lead to more economic links between actors in different service systems, this can be described as *financial alignments*.

5.4 Answering Research Question One

> **RQ1a:** What effects do actors involved in MaaS developments foresee that MaaS will have on personal mobility?

The empirical studies demonstrated that the effects of MaaS are perceived as uncertain, and that three basic rationales regarding the impacts of MaaS are present among the actors involved in MaaS developments. While some anticipated that institutional barriers will hinder MaaS developments and/or that the MaaS concept, if realized, would not appeal to people (MaaS skeptics), a majority believed that MaaS will be realized, and that its introduction will disrupt personal mobility systems. Many (especially strategic actors and new entrants) believed that this disruption will produce sustainability improvements by supporting a modal shift away from private cars towards mobility services (MaaS believers). In contrast, some worried that MaaS developments will harm mobility service providers and public control, and thus reduce personal mobility systems' sustainability (MaaS opponents). Actors who were more vested in the existing personal mobility regimes, such as incumbent mobility service providers, held this latter belief more often than others.

Furthermore, the empirical studies indicated that many actors involved in MaaS developments believe that MaaS will shift the competition between different types mobility services. Commonly, the respondents thought that MaaS developments will support growth of public transport and the mobility services that join MaaS systems, and that mobility services that do not join MaaS services will lose market shares. Next to private cars, traditional taxi was often portrayed as a mode that will regress. The ideas for how MaaS will affect walking and bicycling were mixed.

The empirical studies highlighted that actors involved in MaaS developments generally believe that the introduction of MaaS will support a transformation of personal mobility systems towards more polycentric configurations by strengthening the alignments between service regimes. The respondents proposed several ways in which MaaS can create or enforce such alignments. The introduction of unified gateways to access mobility (such as MaaS apps) can help users comprehend and use multiple mobility services in combination (cognitive alignments). MaaS can also aid and incentivize operational actors across service systems to coordinate their operations (operational alignments), which in turn would force them to collaborate and create stronger bonds between them (organizational alignments). If multimodal travel data is assembled and distributed, this can provide a better overview of personal mobility systems for operational and strategic actors (informational alignments). Finally, MaaS developments demand business models that build on inter-organizational sharing of revenue and MaaS might be used as a tool for extending the distribution of subsidies. Thus, MaaS can create economic links across service regimes as well (financial alignments).

RQ1b: How have these expectations influenced MaaS developments?

The MaaS-believer rationale was dominant across the empirical studies, and inspired much of the private sector investment in MaaS developments. As evident in many MaaS-related policy documents, this school of thought has also influenced the institutional environment for personal mobility in several ways, which have paved the way for MaaS developments. For instance, PTA-VG's general strategy for personal mobility in Västra Götaland, and TfNSW's technology investment plan both drew inspiration from the positive predictions of how MaaS will improve personal mobility systems. The vision of a thriving MaaS landscape that makes travelling easier and personal mobility more effective was moreover central in motivating the reform of transport legislation in Finland. Hence, although MaaS services have not had any direct, significant impact on personal mobility yet, the idea of MaaS has already begun to influence the institutional environment for personal mobility towards favoring alignments across service regimes.

Additionally, the MaaS believers' ideas of how the MaaS concept should be realized provided directionality to MaaS developments. As an example, two prioritized activities in the Swedish roadmap for MaaS developments were that PTAs make their data and sales interfaces available for third-party sales, and that regulations for transport-related taxes and subsidies are adapted to better support mobility services regardless of which sector (public or private) manages them. Both these activities speak to future personal mobility systems with multiple competing MaaS Operators and MaaS offerings, as commonly envisioned by MaaS believers.

However, the MaaS skeptics and MaaS opponents have been reluctant to adopt strategies for MaaS that are based on rationales in which they do not believe. For instance, whether PTAs should open their data and sales interfaces (and if so how and when) has been a contested topic across all the empirical studies. In general, the conflicting expectations and the high degree of uncertainty surrounding MaaS seemed to make it difficult to rally all actors involved in MaaS developments around common MaaS initiatives and goals.

1. See paper E for a more detailed categorization of operational actors.

CHAPTER 6
Institutional Factors

This chapter addresses RQ2: How do institutional factors drive and hinder MaaS developments? Departing from the IRIMS framework (see Section 3.2), it first presents drivers and barriers at the macro, meso, and micro levels separately, based on the evidence from the five empirical studies, prior to providing a summarized response to the question.

6.1 Institutional Drivers

Macro level: A common justification respondents gave for engaging in MaaS developments was that personal mobility systems are changing upon external pressure from several interrelated societal trends; urban populations are growing (Study 4), economies are struggling (Study 2), and the general awareness of personal mobility's pressing sustainability challenges is increasing (Studies 1 and 3). These trends were thought to actualize a need for making personal mobility systems more effective and for fighting their negative externalities, such as congestion (Study 4) and emissions (Studies 1 and 3). Concurrently, it was noted that digitalization and the rise of a sharing economy contribute to the emergence of new mobility services (Studies 2 and 4). The respondents concluded that this increases competition and creates better opportunities to travel inter-modally and multi-modally as well as a greater need to coordinate across service systems. The implementation of new types of information and payment technologies into traditional mobility services, such as public transport and taxi, was said to open opportunities to develop digital apps that can assist people with such coordination (Study 4). It was moreover argued that digitalization coevolves with changes to land-use planning and people's lifestyles and work conditions (etc.) to generate new needs and expectations regarding personal mobility, such as a demand for more convenient, personalized, and enjoyable travel experiences (Study 1). MaaS was talked about as a means for keeping up with all these trends. Those actors who do not proactively invest in MaaS were believed to run a risk of becoming irrelevant.

The respondents also viewed some political trends as favorable for MaaS developments. The Paris Agreement (UN, 2015b) was brought up as an example of a macro-level reaction to sustainability challenges which will eventually trickle down to national and local transport policies and thus prompt local personal mobility systems to focus more on developing less car-centric societies (Study 2); although the national and local policy targets were already considered favorable for MaaS developments. The anticipated effects of MaaS developments (see Chapter 5) were well aligned with many of the much-discussed policy focuses within and beyond personal mobility. For example, in all the empirical studies, looking for ways to lower personal mobility systems' contribution to climate change was thought to increase the interest in MaaS.

The public sector's focus on employing new digital technologies was also often mentioned as driver for MaaS, especially in Finland and New South Wales, Australia. In Finland (Study 2), the technology focus was explained by structural links between transport and digitalization via LVM, by the Finnish front-seat role in the telecommunication industry, and by a push for economic renewal. The latter was said to be a response to the demise of the Finnish economy after the global financial crisis of 2007-2008. As a result of that crisis, finding new opportunities for business development and export was high on the general policy agenda in Finland. In New South Wales (Study 4), the technology focus was simply attributed to a technology enthusiasm among influential politicians and public servants at the state level.

The political climates in Finland and New South Wales were other macro-level factors that seemed to pave the way for MaaS. Major reforms to transport legislation were underway in both these places at the time of the empirical studies (see Section 7.2). Both reforms were, among other things, aiming to deregulate closed markets (e.g. taxi), harmonize regulation across service systems, and facilitate market entry for mobility services (Studies 2 and 4). Moreover, the Finnish reform directly pushed for MaaS developments by requiring mobility service providers to enable third-party resale of their offerings (Study 2). In other words, the reforms aimed to address some of the perceived legislative barriers to MaaS (discussed in the next section). Accordingly, many respondents praised these reforms as *enablers* of MaaS (Studies 2 and 4).

Beyond transport legislation reform, the alignment of policy focuses, political climates, and the anticipated effects of MaaS (cf. Kingdon, 1984) also produced other MaaS-related, public sector activities that have influenced MaaS developments in all five studies. These are discussed at length in Chapter 7. Still, two of them, frequently referred to as imperative for MaaS developments by the respondents, must be mentioned here too. Firstly, across all the studies, public sector actors have funded MaaS research and development projects. The respondents believed that this was fundamental for generating knowledge on MaaS. Secondly, LVM has been vocal in its support of MaaS, which the respondents in Finland believed had pushed a critical mass of people to become excited over MaaS, and increased private investments in Finnish MaaS developments (Study 2). LVM was therefore widely

viewed as spearheading MaaS developments in Finland (Study 2). In contrast, respondents in Sweden and New South Wales noted that the national governments in Sweden and Australia had largely remained uninvolved (Studies 1, 3 and 4).

LVM also helped disseminate the outcomes of Finnish MaaS developments. The global interest in, and media coverage of Sonia Heikkila's master thesis from 2014 and MaaS Global Oy's activities reinforced Finnish MaaS proponents' convictions that MaaS developments are beneficial for Finland (Study 2). This also put pressure on Swedish actors to act sooner rather than later to not fall behind (Studies 1 and 3) and helped spread the interest in MaaS to New South Wales, Australia (Study 4). The Intelligent Transport System Conferences in Helsinki in 2014 and Melbourne in 2016 seemed to have played important roles in spreading the idea of MaaS and in spurring activity.

Meso level: Missions to expand their services pushed both public and private mobility service providers to engage in MaaS developments. Fueled by shareholder expectations and perceived business opportunities, many private mobility service providers wanted to reach new target groups and improve their competitive advantages (Studies 1 and 3). In the public sector, PTAs frequently used a narrative of expanding public transport to achieve broader policy goals. For instance, PTA-VG had a target of doubling the number of public transport trips in Västra Götaland (from 2006 to 2025), which was based on reckoning that this will improve the sustainability of the regional personal mobility system (Study 1).

In addition, PTAs motivated their engagements in MaaS developments with wanting to improve cost efficiency and brand perception (Study 1), wishing to learn about MaaS (Study 4), searching for new ways to attract private investments to public transport (Studies 1 and 4), political decisions (Study 3), and external pressure to act (Study 4). Altogether, the MaaS concept seemed to fit well with the expectations of how public transport should develop, which were manifested in digitally infused policies such as strategies for *intelligent transport* (Study 2) and *smart cities* (Study 4).

A knowledge transfer from digital communication technologies to MaaS was present in Finland. Beyond the previously mentioned structural link within LVM (see Section 6.1), the expertise available (and unoccupied) since the downfall of Nokia Oyj was repeatedly mentioned as a meso-level driver to MaaS development. Many of the MaaS proponents in Finland had previously worked at Nokia Oyj, and now brought their experiences and know-how to MaaS developments (Study 2). As an example, several within the senior leadership at the two, thus far, most acclaimed MaaS Operators in Finland, MaaS Global Oy and Kyyti Oy (formerly known as Tuup), have backgrounds at Nokia Oyj. A similar knowledge transfer was not observed in the other empirical studies.

Another factor that set the Finnish context apart was that many respondents viewed collaboration as a driver rather than as a barrier (Study 2). The collaborative culture in Finland surrounding the reform of transport legislation, and in public-private relations

in general, was praised as conducive to MaaS developments by many of the respondents, several of whom mentioned that a group of influential MaaS champions from both the public and private sectors had been invaluable to Finnish MaaS developments. This group was said to share a common vision for MaaS, and to coordinate their MaaS-related activities through both formal and informal discussion arenas (Study 2). Having learned about the fruitful collaboration in Finland, MaaS proponents in Sweden tried to establish a similar arrangement. A Swedish roadmap for MaaS developments was released in 2017 (KOMPIS, 2017), which featured a series of MaaS meet-ups aimed to promote a climate of collaboration and knowledge transfer. Similarly, the work that led up to the Mobilitetstorget proposal revolved around public-private discussions (Study 3).

Public, meso-level actors, such as the PTAs, have invested in MaaS experimentation. To illustrate, PTA-VG has both funded MaaS pilots and performed technology developments that enable these pilots. MaaS experimentation has moreover been enabled by private investments. In Sweden, the re-launch of UbiGo in Stockholm was powered by an investment from the French business accelerator Via ID (UbiGo, 2019), while in Finland, MaaS Global Oy secured a reported €53.7 million in investments from a wide variety of companies from several industry sectors (MaaS Global, 2019).

Micro level: Representatives for strategic and operational actors across all the empirical studies contended that the appeal of private cars is fading at the micro level. A number of causes were suggested: congestion is getting worse and parking is getting scarcer, which makes it less enjoyable and more time consuming to drive (Study 4); policies aimed at decreasing car traffic such as congestion charges and reduction of residential parking entail that it is getting pricier and more inconvenient to own and use private cars (Study 4); and the awareness of the negative externalities of driving cars, like environmental deprivation and negative health effects, is rising (Study 1). A substantial portion of the general population, especially in cities, is therefore supposedly considering either selling their cars and/or driving less. Furthermore, younger people have become less inclined to take driver's licenses (Studies 2 and 4). Consequently, people are increasingly looking for alternative ways of solving their personal mobility needs (compared to private car ownership).

The field test participants in Study 5 reiterated these suppositions and added that car ownership increasingly is perceived as incompatible with the personal images of modern and enlightened citizens. In parallel, new mobility services have been introduced to cities, creating new travel options. The observed field test in Study 5 indicated that these services are attractive for both car owners and non-car owners. The car owners that participated in the field test said that the new mobility services offered them opportunities to reduce their travel-related expenses and to get rid of the practical and psychological burdens of car ownership, such as maintenance and the risk of theft. Non-car owners talked about saving travel time and hassle since they were able to complement walking, bicycling, and public transport with mobility services better matched with some of their mobility needs.

Additionally, both user types were happy to get access to a wider variety of vehicles, which they thought were more fun to use compared to their previous means of mobility. Overall, the new services, vehicles, technologies, and business models triggered the curiosity of the participants (Study 5).

However, representatives for strategic and operational actors across Studies 1-4 noted that the influx of new types of mobility services could make personal mobility systems more complex and thereby create greater challenges for users in terms of becoming aware of and understanding all the available options. They moreover observed a general trend of rising expectations among users regarding positive and hassle-free use experiences, and concluded that these two developments open a window of opportunity for means that provide a good overview of, and easy access to all the available options in personal mobility systems (Study 1). It was argued that MaaS can address these (new) demands by offering multi-modal travel planners, facilitating payment, and providing a better overview and easier administration of mobility expenses (Studies 1 and 2). If more advanced, MaaS might (even) potentially leverage the multiplicity of mobility services to provide a similar, or better, level of reliability, availability, and flexibility compared to private car ownership (Studies 1 and 2).

The field test participants in Study 5 reinforced the existence of these micro-level drivers for MaaS. The participants wanted to be aware of, have access to, and be able to use all the mobility service options without needing to have a large number of mobility apps on their smartphones. According to them, this is the main added value of MaaS, which among other things could make it easier to try out new travel behaviors. However, other factors pushed them to adopt the trialed service as well, such as moving to a new residence (and thus opening up for new travel behavior), curiosity, a desire to support research and development, encouragement from the MaaS Operator, and promotional campaigns offering cheaper access to the included mobility services (Study 5).

6.2 Institutional Barriers

Macro level: Legislation was one of the most frequently mentioned barrier types, especially by the Swedish respondents. Acts of legislation such as the public transport act (SFS, 2010:1065), the local government act (SFS, 2017:725), the competition act (SFS, 2008:759), and the act on application of state aid (SFS, 2013:388) were perceived to limit the action space of Swedish PTAs (Study 1). As the legislation was commonly interpreted as only allowing the PTAs to plan and mange traditional public transport modes, the PTAs were deemed neither able to operate other mobility services nor qualified to take on the MaaS Operator role (Study 1). Furthermore, regulations that influence the PTAs' potential relations to MaaS Operators have been noted (Study 3). For example, a legal investigation recommended that the PTAs should avoid responsibility structures where MaaS Operators are accountable (to the travelers) for failures related to the public transport trips (Study 3). Additionally, it concluded that PTAs cannot decide which

external MaaS Operators are able to resell their tickets, and that PTAs are not allowed to control how, or how much, MaaS Operators charge users (Study 3) for the resold tickets.

However, MaaS is in a legal vacuum and precedent rulings are missing (RISE, 2019). For instance, there is no legislation on multimodal travelling at the level of the European Union and it is unclear how MaaS Operators should be classified. Which legislation should be applied to regulate MaaS Operators and their relationships with mobility service providers is therefore ambiguous. One result of this legal ambiguity was that interpretations differed regarding what PTAs could do (Studies 1 and 3). While some respondents made the case that PTAs should sit back and let private actors adopt the MaaS Integrator and MaaS Operator roles (Study 2), others believed that PTAs could, and should, broaden their responsibilities (Study 1). In general, the uncertain legislative situation appeared to add to PTAs' inactivity and indecisiveness.

Additionally, the respondents in Sweden identified other acts of legislation that set the boundaries for how public sector actors go about business – such as procurement-related acts (SFS, 2016:1147; 2016:1145) – as barriers to long-term MaaS collaborations between PTAs and other actors. These acts of legislation, and the collaboration models and processes they cater to, were perceived to not support inter-organizational collaboration, joint decision-making, and learning by doing (Study 1). In particular, the respondents emphasized that these acts hinder the transition from *no rules apply* pilots to *all rules apply* operations (Studies 1-4).

Looking beyond PTAs, respondents often described the personal mobility systems as heavily regulated. Much of the regulation is based on traditional categorizations of services and vehicles. Consequently, it was perceived as difficult to introduce mobility services that employ new business models and/or vehicles (Studies 2-4). Respondents described the ordeals of ride hailing, e-scooter sharing, and peer-to-peer car sharing as examples to back up this point (Study 2). Furthermore, the lack of definitions for new types of mobility services was thought to make it difficult for public sector actors to facilitate their diffusion. Among other things, municipalities have limited possibilities to reserve parking spaces for car sharing in Sweden (since they struggle with distinguishing what is a car sharing car), which in turn impedes car sharing's user appeal (Study 3). The appeal of car sharing in Sweden is moreover hampered by a high value-added tax and taxation regulations regarding company cars and work commuting. Respondents frequently held these regulations as examples of institutional conditions that favor private car ownership and use (Study 3).

Much of the legislation discussed by the respondents in Sweden are based on European Union directives (e.g. the definition of public transport). Actors involved in MaaS developments in Sweden therefore perceived the possibilities to change acts of legislation as limited (Study 1). This implied that solutions that may go against these acts were not even considered worth trying.

The respondents noted that the multitude of public sector actors involved in the governance of personal mobility systems added to its complexity (Studies 2 and 4) and hampered MaaS developments (Study 3). For example, the fact that the responsibilities for personal mobility and land-use planning often are distributed to different public sector actors was brought up as a barrier to MaaS developments since MaaS requires (synchronized) changes in both realms (Studies 1-4). Moreover, as much of the transport planning responsibilities lie with the local and regional levels of the public sector, large local variances ensue, which impede the development of national or international MaaS services (Studies 2 and 4). In particular, the respondents emphasized how the organization, planning, operation, and financing of public transport differ, and how this makes it difficult to integrate several public transport offerings into one MaaS service (Studies 2 and 3). Generally, the respondents thought that the involvement of different public sector actors with different agendas and responsibilities certainly implied that there will be some conflicts of interest. Some went so far to say that institutional conditions in more authoritarian countries than Sweden, Finland, and Australia are more conducive to MaaS, as such national governments usually have greater unilateral discretion to decide on development trajectories (Study 2).

In New South Wales (Study 4), the issue of divided responsibilities seemed to be less pressing compared to in Sweden and Finland. In Australia, state governments control many of the important transport regulations and operate most of the public transport network. They also plan much of the transport infrastructure and oversee other developments that are considered to have statewide relevance. Hence, state-level transport authorities (such as TfNSW) have greater possibilities to enable or prevent MaaS developments, compared to their counterparts in Sweden and Finland. Still, there are conflict of interest across different strands of government and across agencies, which create macro-level challenges for MaaS developments in Australia as well (Study 4).

Beyond the dissimilarity in how the public sectors are organized in the different countries, some geographical and demographical differences seemed to influence the respective MaaS developments. Both Sweden and Finland were described as small and scattered markets with few major cities. This was perceived to make it difficult for MaaS Operators to develop viable business models, as well as tougher for them to attract venture capital (Studies 2 and 3). However, in Finland, the country's small size was also believed to contribute to it being an appropriate test market, as well as contribute to the previously discussed collaborative culture and shared vision for MaaS. Helsinki's central position as the main place for MaaS developments in Finland was moreover viewed as favorable, since this means that all key players are gathered in the same place. This can be contrasted with the situation in Sweden, where Gothenburg and Stockholm were considered to compete over that reputation (Study 2). Another factor put forward as disadvantageous for MaaS developments in Sweden was the automotive industry. Respondents from Finland mused that the dependencies of jobs and tax revenue from the automotive industry might hold the Swedish public sector back from structural reforms that would benefit MaaS at the expense of private car use (Study 2).

In comparison to Sweden and Finland, New South Wales was described as a larger market that is attractive to private mobility service providers and investors (Study 4), although it was noted that it is mostly Sydney that draws this attention. Like the other two contexts, New South Wales has both urban and rural areas. Since rural areas on average are very car centric (Studies 2 and 4) and less profitable for mobility service providers (Studies 2 and 3), the respondents believed that both mobility service providers (Studies 1-4) and MaaS Operators are much less interested in launching their services there (Study 1). In other words, MaaS was not anticipated to become available everywhere for everyone. However, all three contexts are well-off from a global perspective and have high rates of Internet and smartphone adoption, which were believed to facilitate a widespread diffusion of MaaS.

Meso level: The intricate inter-organizational collaboration process was one the most cited barrier types in Sweden (Studies 1 and 3). Several reasons as to why it was complicated were suggested and seemed to apply across all the empirical studies. Firstly, the MaaS concept builds on collaboration between actors of different types (e.g. public and private) that have not collaborated before (Study 1). Consequently, the process of building up inter-organizational trust and understanding becomes extra difficult (Studies 1 and 2). Furthermore, several of the mobility service providers (both public and private) are presently in monopoly-like positions and perceive few incentives to participate in or support MaaS developments (Studies 3 and 4). Secondly, MaaS introduces new roles (MaaS Integrator and MaaS Operator), but respondents disagreed on whether the public, private or both sectors should adopt these, which created significant inter-organizational tension (Study 1). For instance, it was debated whether or not the PTAs would be biased if they adopted the MaaS Operator role (Studies 1-4). Thirdly, personal mobility was described as a low-margin industry (Studies 1 and 3) in which many services are subsidized in one way or another. This fueled a worry of misuse of subsidies (Study 2) and impeded agreement on business models for MaaS (Studies 1-4); to develop viable business models was in general described as the *Gordian knot* of MaaS developments (Study 1). The diffusion of MaaS was also estimated to be a costly process, and it was unclear how it should be funded (Studies 1 and 2). Fourthly, the effects of MaaS are uncertain and some worried that its diffusion will prove to be negative for society and/or for some of the involved actors (see Section 5.1). Above all, there was pronounced concern among incumbent mobility service providers that they could lose contact with users (Studies 2 and 3), and/or access to user data (Studies 2 and 4), and thereby lose business intelligence. Indeed, next to business models, how to share the user relationship and user data were two of the most contested topics[1]. Additionally, referencing the dominant positions of meta-search engines in the car rental and hotel industries, many incumbent mobility service providers expressed a risk of becoming dependent on prominent MaaS Operators for getting into contact with potential (new) users (Studies 1-4).

In addition to the inter-organizational challenges, respondents felt that the PTAs faced multiple organizational barriers. PTAs were described by many as unfit for the task of driving collaborative innovation processes such as MaaS developments (Studies 1-4). PTA representatives often talked about the structure of their organizations being set up for the

traditional task of operating public transport, and that this entailed a lack of innovation culture and increased organizational inertia when it comes to disruptive innovation tasks such as MaaS (Studies 1 and 4). The political leadership (Studies 1 and 3) and the administrative burden (Study 1) were thought to contribute to this, especially in the case of HSL, which is governed by nine different municipalities (Study 2). Furthermore, the PTA representatives found it difficult to prioritize their limited resources toward MaaS over other development tasks (Studies 1-4), and hard to establish a shared vision and strategy across large organizations such as PTAs (Study 4). Other actors were not as forgiving. Several respondents viewed the PTAs as risk-averse protectionists. More broadly, the public sector was seen by many as inept or lacking when it comes to user-centric innovation (Studies 1, 2 and 4).

The PTAs' MaaS strategies, or the lack thereof, were much discussed among the respondents (Studies 1-4). TfNSW's long-term transport strategy (TfNSW, 2016a) illustrated TfNSW's interest in MaaS and indicated a path for MaaS developments (Study 4). Correspondingly, the PTA of the Stockholm region (Region Stockholm) released a MaaS strategy document in 2016 (Region Stockholm, 2016) that clarified the opportunities and limitations for MaaS actors in Stockholm (Study 3). However, neither PTA-VG nor HSL had released MaaS strategies at the point of data collection for Studies 1-3, which led to speculation as to their intentions. Relatedly, the lack of opportunity to resell public transport tickets was put forward as a major barrier to MaaS developments (Studies 1, 2 and 4). Fundamentally, many respondents believed that public transport is central for MaaS, but that actors other than the PTAs should take on the MaaS Operator role. Thus, the possibility to resell (digital) public transport tickets was in their view a vital component for MaaS developments.

HSL developed a generic contract for third-party resale of its single tickets and signed such a contract with MaaS Global Oy in 2016, which enabled the operation of Whim and opened for MaaS experimentation in Helsinki (Study 2). Likewise, PTA-VG developed and signed a similar contract in 2019, which enabled new MaaS pilots in Västra Götaland. Representatives for both HSL and PTA-VG described the processes of drafting and negotiating these contracts as hard, as they had limited prior experience of this type of arrangement, and since it is difficult to negotiate contracts for new things with uncertain outcomes (Studies 1 and 2). The reception of the contracts has been lukewarm thus far. The first version of HSL's contract only permitted resale of unsubsidized single tickets[2], which was perceived to limit MaaS Operators' opportunities to offer attractive bundles. Furthermore, volume discounts were not given, which many respondents held as a precondition for viable MaaS businesses (Studies 1 and 2). In the case of PTA-VG, its contract was only signed with two MaaS Integrators; thus, it has not (yet) accommodated the vibrant MaaS landscape that many respondents envisioned. Moreover, neither of the contracts enabled the resale of new types of public transport tickets[3]. Among respondents in Sweden, this was a hotly debated topic since the UbiGo pilot in Gothenburg had featured a unique and much-appreciated daily ticket (Studies 1 and 3).

The integration of data and payment systems was described as challenging no matter what public transport tickets were included (Studies 2 and 3). The MaaS concept builds on integration across different service systems, many of which were not yet fully digitalized (Studies 2 and 4). Moreover, pricing models were different across the service systems, and there were no widespread technical standards (Study 1); hence, the generalizability of technical solutions was perceived as limited. MaaS also places high demands on data quality and data security, in some cases higher than what the available digital infrastructure could produce (Studies 2 and 4). In addition to these technical challenges, there were contractual barriers to data and payment integration. The PTAs usually had ongoing, long-term contracts with external suppliers that operated their data, ticketing, and validation systems. In some cases, MaaS was deemed out of scope, or blocked by these contracts (Study 4). The data, ticketing, and validation systems are moreover central to the operation of public transport, which made the PTAs reluctant to experiment with them (Studies 4 and 5).

Micro level: MaaS was often positioned as an alternative to private car ownership and use (Studies 1 and 2). Accordingly, the institutional factors reinforcing private car ownership and use were perceived as barriers to MaaS. At the micro level, such factors included existing travel habits and a culture of car ownership (Studies 1-4). Furthermore, many potential MaaS users were trapped in travel patterns that included long and/or frequent trips to destinations with limited public transport access, and such trips were hard to cover with the available mobility service offerings (Study 5). A private car was therefore perceived as the most cost-effective alternative for many (Studies 1-3), which was fortified by an underestimation of the costs of private car ownership (Study 4). The user problems associated with private cars (e.g. congestion and finding a place to park) were moreover deemed as manageable in the studied contexts and thus not pushing for a move away from car-centric travel behavior (Studies 2 and 4).

The tested and planned MaaS services across the five empirical studies shared some features which limited individuals' access to and full use of them: the main communication channel was typically an app, thus requiring access to, and skills in using, the Internet and a smartphone; most payment methods required access to a bank card, which economically disadvantaged persons, as well as children, often do not have; and the MaaS services often included urban car sharing and car rental schemes as core mobility services, thus limiting users who do not live in or near a city, and do not have driver's licenses and good credit ratings. In other words, the tested and planned MaaS services only targeted subsets of the general population.

Even for those individuals within the (intended) target groups, the adoption process has been far from barrier free. Those who tried the piloted MaaS service in Study 5 reported that the on-boarding process was tedious, and that it was difficult to learn how to operate all the components of the MaaS service as well as difficult to carry out some of the practical tasks related to using the service; such barriers were particularly

troublesome for older people and non-native speakers. The difficulty in understanding the division of responsibilities between the network of actors behind the MaaS service was more universal. This risk was reiterated in several of the empirical studies (Studies 3 and 4). Other user complaints in Study 5 included a poor experience when using the app, and that the rules of use were incompatible with how users wanted to use the included mobility services. By and large, it was evident that the piloted MaaS service needed significant fine-tuning to match the users' expectations. The users were aware that the MaaS service was under development and was being piloted rather than operated on a continual basis, and for some, this triggered a wish to support the project, but for others, this increased skepticism and lessened interest in investing time in adopting the service (Study 5). The limited time span of the pilot (twelve months) was also a concern, since the adoption process required substantial effort and was quite time-consuming. Finally, the users raised several concerns that the MaaS Operator was not able to address, such as the risk of bicycle theft and that the local transport infrastructures did not support bicycling and walking (Study 5).

6.3 Answering Research Question Two

RQ2: How do institutional factors drive and hinder MaaS developments?

Institutional factors at the macro, meso, and micro levels were recognized to affect MaaS developments in many ways across the empirical studies. An overview of the most significant drivers and barriers to the development and diffusion of MaaS are provided in Table 2 (on pages 62-63) and summarized below.

Drivers: At the macro level, respondents felt that societal trends have put pressure on personal mobility systems. Policymakers have responded differently to these trends, but there seemed to be a general will to implement policies aimed at facilitating a shift from private cars to mobility services and active mobility. Some policymakers have also picked up an interest for MaaS and tried to push for MaaS developments by funding research and development and by reforming legislation. In parallel, an influx of new mobility services into urban areas has created new opportunities to travel multi-modally, thus necessitating increased coordination between different mobility modes (i.e. across service systems). Novel information and payment technologies have opened new opportunities for developing digital solutions, such as MaaS services, that can help users with that (i.e. coordinate their travel). The opportunity to tap into customer segments that meso-level mobility service providers can not attract on their own was a common reason for their interest in MaaS. In addition, mobility service providers worried about falling behind if one chooses to not jump on the MaaS bandwagon. At the micro level, the user appeal of private cars was said to be falling (for some). Together with changing lifestyles and needs, and a greater attention to environmental sustainability and personal health, this has made users more interested in alternative means to solve their personal mobility needs.

Barriers: At the macro level, respondents felt that interpretations of legislation have reduced the PTAs' perceived action spaces and hampered both MaaS developments and the diffusion of mobility services that could become vital parts of MaaS. Varying population densities (urban – rural) and the fragmentation of personal mobility systems into small geographical markets have impeded the development of universal MaaS services. The meso level was characterized by inter-organizational wariness and anxiety, as the MaaS developments brought together public and private actors that had not collaborated before, and required changes to collaboration processes, business models, and user relations. On top of that, the effects of MaaS remained uncertain. As a result, it was difficult for PTAs (and others) to prioritize MaaS over development projects with more predictable results. Additionally, several key practical enablers of MaaS were yet to mature. For example, not all data and ticketing systems were fully digitalized, and the technical interfaces were not yet harmonized. At the micro level, the entry requirements for the tested MaaS services excluded many potential users, and the included mobility services were not perceived as offering a viable alternative covering all travel needs, such as long daily commutes that cannot be performed with public transport. Habitual car ownership and use seemed difficult to break in general. Moreover, the users that entered the adoption process in Study 5 struggled with understanding and using the MaaS service. A more fine-tuned MaaS service as well as modifications to local personal mobility systems would have been needed to fully match their needs and expectations.

Table 2. Institutional factors that have affected the development and diffusion of MaaS

Level	Institutional drivers	Institutional barriers
Macro	Formal Influx of new types of mobility services Policy focus on combating private car culture Digitalization of personal mobility systems Deregulation and harmonization of transport regulation (Studies 2 and 4) Regulation requiring mobility service providers to open up for third-party resale of tickets (Study 2) Public funding of MaaS-related R&D Informal Societal trends that put pressure on personal mobility systems to change Global attention to and diffusion of MaaS ideas Vocal public sector support of MaaS (Study 2)	Formal Legislation limiting the perceived action spaces of PTAs (Studies 1, 3 and 5) Legislation hindering the diffusion of mobility services Legislation impeding long-term public-private innovation collaboration Division of public sector responsibilities creating conflicts of interest and synchronizing problems Varying population densities and small target markets making universal MaaS services infeasible Limited geographical coverage of mobility services Informal Dependencies of the automotive industry (Studies 1 and 3)

Level	Institutional drivers	Institutional barriers
Meso	Formal Third-party resale contracts for public transport tickets (Studies 2 and 5) Public and private investments in MaaS developments Mobility service providers' missions to increase the use of their services Informal Worry of being left behind Knowledge and resource transfer from the telecommunication industry (Study 2) Collaborative culture across public and private sectors and strong networks of MaaS champions (Study 2)	Formal Public transport tickets not available for third-party resale Large costs associated with MaaS diffusion High demands on digital infrastructures Lack of standards for technical interfaces Existing contractual relations (Study 4) Lack of viable business models for MaaS (also informal) PTAs not organized for collaboration (also informal) Informal Different ideas of division of responsibilities High levels of uncertainty Anxiety and inter-organizational mistrust Few incentives to participate for key actors Difficulties in prioritizing MaaS within PTAs
Micro	Formal Growing costs of traveling by private car Worsening traffic and parking situations Greater need to coordinate across several service systems Informal Growing attention to environmental sustainability and personal health Curiosity in novel technologies, vehicles, and services Changing expectations and attitudes	Formal Travel patterns mismatched with mobility service offerings (long and/or frequent trips) Expensive and urban services that require driver's licenses, smartphones, and bank cards Transport infrastructures not supporting active mobility Informal Few incentives to change current travel habits Habitual car use and a culture of car ownership Difficulties understanding and using MaaS services (Study 5) Mismatches between needs and rules of use (Study 5) Poor user experience and missing functionalities (Study 5)

1. A formal factor at the macro level contributing to this concern was the enforcement of the general data protection regulation (GDPR) in Europe, which came into effect in 2018. GDPR forces actors handling personal data within the European Union to be more structured and transparent regarding how data is assembled, processed, stored, and shared. Thus, it was interpreted by some respondents to make data sharing more cumbersome.
2. In Finland, public transport subsidies are organized at the local level, which implies that the PTAs must know where the users are registered if subsidized tickets or passes are to be sold. Single tickets are not subsidized.
3. In New South Wales, this was a non-issue as public transport payment is based on a capped distance-based, pay-as-you-go system and, thus, does not include any transit passes (i.e. period tickets that allow users to take unlimited trips within a fixed period of time).

CHAPTER 7
Public Sector Activities

This chapter addresses RQ3: (a) What have public sector actors done in relation to MaaS developments, and (b) how have these activities shaped MaaS developments? It therefore presents what activities public sector actors have performed in the empirical studies, and what effects have been observed. Departing from the Transition Management Framework (see Section 3.3), strategic, tactical, operational, and reflexive activities are first discussed separately, prior to a summarized response to the questions.

7.1 Strategic Activities

The respondents in Sweden (Studies 1, 3 and 5) seldom spoke of any strategic-level public sector activities. Public sector activities that addressed the strategic level had likely not sufficiently included the operational MaaS actors in the processes and were perceived as either too broad or too narrow in their focus to offer guidance. For example, the vision of *a good life* in Västra Götaland (VGR, 2005) had an overall focus on regional development and only involved public sector actors at the regional and local levels in the decision-making process (Study 1). Hence, few respondents made any connection between this vision and MaaS developments. Similarly, the collaboration program for the Next Generation's Travel and Transport, which was based on the vision that Sweden should be the world's first fossil-free welfare country (Regeringskansliet, 2016), failed to establish links between this fossil-free vision and tactical and operational MaaS-related, public sector activities (Study 3).

To the contrary, respondents in the two other empirical studies frequently referred to collaboratively developed long-term visions for personal mobility systems. In Finland (Study 2), the Transport Revolution Program launched in 2010 was seen as the springboard for the more focused MaaS work that would follow. The program aimed at developing a new mindset for transport planning and policymaking to ensure sustainable growth, competitiveness, and wellbeing. The program proposed a move away from a production-centered mindset and infrastructure- and sector-specific polices, to a governance approach informed by systems thinking and centered on service quality and user needs (LVM, 2011a; 2011b). The development of this new way of thinking

coincided with the launch of national strategies for *intelligent transport* (LVM, 2009; 2013) and the founding of a think tank on future mobility in which public and private forerunners discussed transport policies[1]. Supposedly, it was in this think tank that the idea of MaaS was first introduced in Finland. The sum of these public sector activities led to a shared understanding among a strong group of MaaS champions of what future personal mobility systems may look like, how MaaS could contribute to that future, and what was needed to pave the way for MaaS (Study 2).

Also, in New South Wales, Australia (Study 4), TfNSW's long-term transport strategy, Future Transport 2056, was raised as the vision that guided MaaS developments. Together with infrastructure and land-use strategies (e.g. GSC, 2018), this transport strategy envisioned a future in which personal mobility is "an enabler of economic and social activity and contributes to long-term economic, social and environmental outcomes" (TfNSW, 2016a, p. 14). User experiences in future dynamic personal mobility systems should be seamless, interactive, personalized, and supported by technology and data. "Moving to MaaS and beyond" (ibid., p. 15) was pinpointed as a prioritized development to accomplish this; "personal mobility packages will bundle traditional modes with technology platforms and new service offerings like on-demand, car share, rideshare, and smart parking", and people will "make travel choices based on factors that matter most to them – service frequency, cost, emissions, comfort, or travel time" (ibid., pp. 15-16). Although this vision was developed in close collaboration with citizens, the private sector, and local councils, it was primarily public sector actors that referred to it during the interviews. Other involved actors felt more uncertain of what future personal mobility systems will look like, and what roles MaaS will play in them (Study 4).

7.2 Tactical Activities

The empirical studies demonstrated a wide variety of tactical-level, public sector activities perceived to either pave the way for MaaS developments directly or influence personal mobility systems in ways that indirectly cater for MaaS developments. Broadly, these activities can be catalogued as action plans, regulatory reforms, collaboration forums, and technology developments.

Action plans: In Sweden, coordination of the PTAs' MaaS-related activities was achieved through several interrelated processes. A national roadmap for MaaS was developed at the request of the collaboration program for the Next Generation's Travel and Transport. The roadmap stipulated four areas of short- and mid-term activities and linked these to performance and impact targets. The four areas comprised developing a digital infrastructure for third-party resale of mobility service providers' offerings (primarily public transport); addressing legislation, policy, and transport infrastructure barriers; experimenting with MaaS in urban and rural settings; and developing a framework for impact analysis (KOMPIS, 2017). However, despite later being endorsed by the Swedish Transport Administration, the Swedish Energy Agency, the Swedish Innovation

Agency, and the Swedish Public Transport Association, the roadmap was developed by a small group of so-called experts. Thus, the process had not included many with the authority to influence the MaaS-related actions of incumbent mobility service providers. Conversely, Samtrafiken AB hosted several processes in which PTAs and other strategic and operational actors discussed a digital infrastructure for sharing data and tickets (i.e. the first area of the roadmap). In particular, the Swedish Mobility Program (Samtrafiken, 2017) was identified as a process which facilitated inter-organizational synchronization (Study 3). Additionally, the PTAs for the capital regions in the Nordic countries plus the PTAs for Västra Götaland (PTA-VG) and Skåne in Sweden established a discussion forum through which they compared their governance approaches to MaaS.

Several PTAs augmented their MaaS plans in organizational-level strategy documents. TfNSW's roadmap for technology developments was perhaps the most comprehensive example in this regard (TfNSW, 2016b). Departing from the Future Transport 2056 strategy (discussed in Section 7.1), the roadmap described five scenarios for developing the personal mobility system in New South Wales, and identified 15 technology developments that TfNSW planned to invest in since they were believed to be of value no matter which scenario would unfold. The roadmap also outlined what type of governance approach TfNSW planned to take in relation to each investment. For instance, one identified technology development was to create joint digital channels for all mobility services in New South Wales. To achieve this, TfNSW planned to take the role as an early adopting service provider, which entailed that TfNSW would develop and deliver these digital channels (either directly or via procurement) and were prepared to adopt relatively new technologies. The spirit of the roadmap was communicated via many different means, such as a leaflet and a series of YouTube videos. While a few involved actors mentioned that this helped them plan their MaaS-related activities, many involved actors still felt unsure of TfNSW's underpinning intentions and objectives and thus found it difficult to predict how the activities of TfNSW would influence their plans (Study 4).

In Sweden, Region Stockholm published a MaaS strategy document in late 2016 (Region Stockholm, 2016). It clarified Region Stockholm's intentions of supporting MaaS pilots in Stockholm and its role as a mobility service provider in the emerging MaaS value chain (Study 3). In other words, Region Stockholm did not plan to adopt either the MaaS Integrator or MaaS Operator roles itself. Similarly, PTA-VG has published several annual plans that have dictated its strategy of facilitating MaaS developments by enabling and supporting externally managed MaaS services (VGR, 2017; 2018; 2019c). Still, both representatives for the PTAs and many other involved actors pointed out conflicts across these strategies and the actions taken by the PTAs. Although MaaS was identified as a prioritized area of development in many key steering documents, this did in many cases not translate into concrete decisions and development activities. Consequently, the Swedish PTAs' strategies for MaaS developments were generally considered as vague and inconsistent (Studies 1, 3 and 5). In Finland, HSL was working on a strategy at the time of data collection (Study 2).

Regulatory reforms: Several regulatory reforms and decisions at the national, regional, and local levels were perceived to facilitate MaaS developments, intentionally or not. The most discussed regulatory reform, in Finland and elsewhere, was the Finnish Transport Code reform (Finlex, 2017:320). This reform brought transport regulations together under one act. The communicated objectives were to lighten and harmonize regulations and to promote the introduction of new digital technologies and innovative business concepts that better meet the needs of people. Due to its wide-ranging content, the reform was carried out in three stages, the first of which came into force in 2018. Among other things this stage deregulated the taxi regime. It also demanded that all providers of road- and rail-based mobility services in Finland, including brokering and dispatch organizations, give third parties access to the sales interface of their ticketing and payment systems and to allow them to resell ticket products for single trips (this has since been extended to include more types of ticket products). In other words, LVM actively forced mobility service providers to enable externally managed MaaS services. The reactions to this have been many and varied, ranging from contestation (e.g. from taxi unions) to admiration (e.g. from the Intelligent Transport Systems community). A majority of the Finnish respondents thought, however, that the reform paved the way for MaaS developments (study 2). In terms of concrete impacts, LVM concluded that, by the end of 2018, the number of taxi companies and taxi chauffeurs had increased considerably. Taxi services and pricing models seemed, moreover, to have diversified; and many mobility service providers had made travel data available and/or started the work on opening their sales interfaces (LVM, 2018).

The first Finnish mobility service provider to open its sales interface was HSL. Pushed by the impending Transport Code reform, and by the actors involved in the reform process, HSL developed generic contract terms for third-party resale in 2016 (Study 2). A contract was also signed with MaaS Global Oy the same year. In short, the first version of the contract enabled third parties to resell eight types of single, adult, public transport tickets. Also, HSL neither charged any fees, nor offered any compensation for ticket sales. A few respondents criticized the terms of the contract (Study 2). Fundamentally, they believed that HSL had made the smallest possible effort to comply with the upcoming reform, but that the exclusion of the subsidized transit passes made it impossible for MaaS Operators to develop viable business models (see Section 6.2). HSL has since updated the contract terms to also include its transit passes.

The respondents in New South Wales pointed out past and ongoing regulatory reforms as important for MaaS developments there as well (Study 4). A new passenger transport act had been introduced in 2014 (NSW Government, 2014) and, compared to its predecessor, was recounted as being less focused on vehicle and service categories and more on preferred outcomes. TfNSW's regulatory approach seemed to undergo an overall shift towards giving the private sector more freedom to innovate and greater opportunities to weigh in on TfNSW's actions. This was manifested in increasingly collaborative planning processes, multimodal tenders, flexible bus contracts, and a

collaboration program entitled the Regulatory Sandbox Initiative, which enabled tests of regulatory responses to new products and services. The idea of giving more leeway for experimentation also influenced how TfNSW approached the arrival of new modes. Having monitored the rise of ride sourcing for a couple of years, taxi legislation was replaced by a broader legislation for taxis and hire vehicles in 2016 (NSW Government, 2016:34). Entitled the Act on Point-to-Point Transport, this reform made ride sourcing lawful, reduced licensing requirements, and increased the accountability of the involved private actors. The effects thus far include a surge in the number of chauffeurs and more niche services being brought to market (Study 4). The regulation of bicycle sharing programs followed a similar trajectory.

In Sweden, a few recent public sector investigations have looked into topics relevant to MaaS, for example on measures to promote the diffusion of shared mobility services (Regeringskansliet, 2020a) and on a national ticketing system for public transport (Regeringskansliet, 2020b)[2]. Respondents argued nonetheless that Sweden is yet to witness any significant changes to national transport legislation that can facilitate MaaS developments. Instead, the regulatory activities mentioned were at the regional and local levels. For instance, municipalities' use of flexible parking norms opened for alternative ways to offer personal mobility. However, the most discussed regulatory activity was PTA-VG's decision to procure a MaaS service, and the procurement process that followed (Study 1). While a few involved actors supported the approach, many contested its search for a single MaaS service, based on the argument that it would be better for both MaaS developments and people if one let a hundred (MaaS) flowers bloom. The applied traditional procurement process was moreover deemed as mismatched with the high level of uncertainty of MaaS developments (cf. Smith et al., 2017).

Collaboration forums: As indicated throughout this chapter, several formal and informal collaboration forums were used to disseminate and discuss MaaS visions and to coordinate and coproduce public sector activities at the tactical and operational levels. In Sweden, examples of influential forums include the Swedish Mobility Program (Study 3), meet-ups organized by the program committee for the national MaaS roadmap (Study 3), the meetings between Nordic PTAs, and research and development projects. In Finland, the think tank on future mobility and more informal Thursday night MaaS discussions were put forward as formative events (Study 2). Additionally, the public sector in Finland has co-founded a growth program for MaaS aimed at challenging Finnish companies to seize the global business opportunities of MaaS, as well as an international interest group (MaaS Alliance) that aims at creating a foundation for a unified approach to MaaS developments (Study 2). The non-profit association ITS Finland has also played a significant role in Finnish MaaS developments, as it organized the processes that led up to the founding of MaaS Global Oy (then MaaS Finland Oy) and has actively disseminated its vision of MaaS. Furthermore, the hosting of international conferences on Intelligent Transport Systems seemed to catalyze interest in MaaS and MaaS developments in both Finland and Australia (Studies 2 and 4).

In New South Wales, the Digital Accelerator Program organized by TfNSW was perceived as central to MaaS collaboration. The ongoing program attempts to support and fast-track the initiatives pinpointed in the roadmap for technology developments by offering a milieu and a process for understanding problems, ideating, prototyping and testing services, and transitioning from trials to operations (TfNSW, 2018c). While some respondents argued that the program was little more than a place for futile hackathons, others thought it provided an inspiring venue for public-private innovation partnerships (Study 4).

Technology developments: The MaaS developments in the five empirical studies were embedded in a general digitalization of personal mobility systems. Especially, the digitalization of public transport was identified as imperative for MaaS developments. PTAs' launches of, and improvements to, third-party development portals, open application programming interfaces, and public transport travel data were applauded across all the empirical studies since MaaS Operators need access to timetables and quality, real-time data to develop reliable travel planning functionalities. The PTAs also introduced new digital channels for planning and paying for public transport in all the empirical studies. Quite recently, both PTA-VG and HSL launched smartphone apps through which one can search for public transport routes and buy public transport tickets, while TfNSW has digitalized its community transport system and improved its travel planning app in parallel to developing a state-wide payment framework (including possibilities to pay by *blipping* a bank card). These initiatives have pushed the PTAs to digitalize their ticketing systems, and, at least in theory, this enables the inclusion of public transport tickets in MaaS apps (all studies).

To help external MaaS Operators integrate public transport tickets, PTA-VG has moreover developed an application programming interface for its ticketing system (and auxiliary functionalities), which adheres to a nationally adopted technical standard for public transport ticketing and payment (Samtrafiken, 2019). This standard was considered a good way of lowering the technical integration costs (Study 3). However, despite the development of a standardised application programming interface, the integration work was still perceived as too complex to enable speedy MaaS developments and viable business models (Study 5). In an analogous process, HSL developed a so-called open MaaS application programming interface (HSL, 2018). This initiative has been criticized for not enabling deep integration and for requiring prepayments for tickets (Study 2). Further, both PTA-VG and HSL were perceived as not giving third-party resellers satisfactory information on upcoming changes (Studies 2 and 5). Respondents across all the empirical studies criticized the PTAs for not being open-minded and transparent when it comes to their technology developments.

Another contested technology-oriented activity was the attempt to launch a national MaaS Integrator in Sweden, which would collect information from mobility service providers and distribute these to MaaS Operators via a single contract and a single technical integration (Study 3). The idea was that an intermediary one-stop shop for

data, tickets, and contracts would lower the entry barriers for both mobility service providers and MaaS Operators. The proposed intermediary was to have three functions: technical, business, and process facilitation. The technical function involved a platform for sharing of data and ticket offerings. Respondents in Sweden anticipated that this platform would streamline involved actors' investments in MaaS developments but foresaw that it would inhibit the quality of MaaS services, add unnecessary costs, and impair commercial potential as well. These expectations contributed to the decision to cancel its development (Study 3).

7.3 Operational Activities

The five empirical studies encompassed many experiments in which public sector actors were involved to different degrees. These experiments were fundamental for pushing the MaaS developments forward and significantly impacted the innovation trajectories as well as the surrounding rhetoric. The publicly funded 2013-2014 UbiGo pilot in Gothenburg ignited the interest in MaaS in Sweden, and the dissemination of its results have had substantial impact on MaaS developments elsewhere. For example, the pilot evaluation is referenced in TfNSW's transport strategy as an indication of MaaS developments being beneficial for public transport (Study 4). Furthermore, in Finland, the fall out that followed the UbiGo pilot (see Chapter 2) was used as an example of why PTAs should not take front-seat roles in MaaS (Study 2). Several public sector actors at the national, regional, and local levels in Sweden have since funded a diverse range of ongoing and future MaaS pilots (Studies 2, 3 and 5). Private actors have in most cases adopted the MaaS Operator role in these pilots. An exception to this is an ongoing pilot in Gothenburg that integrates public transport and car parking. This functionality has been developed by the municipality-owned local parking company and is integrated into its smartphone app for parking.

While the UbiGo pilot was the first comprehensive example of MaaS, it is the operation of Whim in Helsinki that has spread notion of MaaS around the world. This operation is one of several MaaS pilots that have received funding from the Finnish Innovation Agency. It has also benefited from more informal but vocal support from LVM and the City of Helsinki. These organizations have extensively used Whim as the prime example of what successful MaaS may look like (Study 2). Other MaaS pilots that received funding from the same call include Tuup, Reissu, Ylläs Around, and Kätävä (Study 2). To the contrary, until recently New South Wales had not experienced any MaaS pilots. A first, research-driven pilot was introduced in November 2019 (iMove, 2019), and TfNSW has funded five more that are to commence shortly (TfNSW, 2018b).

MaaS pilots have been criticized for a variety of reasons. For instance, the UbiGo pilot included a unique daily public transport ticket, which influenced the participants' attitude towards the service (Study 1); the Whim operation has not been transparently evaluated (Study 2); and the pilots that TfNSW are planning represent MaaS components rather

than comprehensive MaaS services (Study 4). Nonetheless, MaaS pilots have been major sources of enthusiasm and have generated a lot of knowledge. This includes both factual learning regarding MaaS and higher-order learning about MaaS developments (e.g. how to market MaaS, and how to organize MaaS partnerships). Pilots of related concepts, such as on-demand services, have also contributed in this regard (Studies 2 and 4).

7.4 Reflexive Activities

Several of the previously mentioned public sector activities have incorporated reflexive work. Much of the tactical activities have included elements of collaborative future thinking. The scenario analysis that led up to PTA-VG's decision to procure a MaaS service provides a good example in that regard; actors seen as influential and knowledgeable were invited to discuss how MaaS developments could evolve and what implications different scenarios may have (Study 3). Besides such embedded reflexive components, the public sector actors in Sweden, Finland, and Australia have invested in activities solely centered on investigating pathways forward. For example, legal explorations at both the national and regional levels have informed what pathways are feasible in Sweden (Study 3), and the Finnish Transport Agency set out early on to explore how MaaS developments had been progressing and were likely to progress, to choose best course of action to create a *MaaS Valley*, i.e. an environment that facilitates MaaS experimentation and therefore entices private investments in Finland (Study 2). Furthermore, public sector actors are monitoring ongoing MaaS developments: in Finland, LVM is observing the impact of the Transport Code reform (Study 2); in Sweden, a framework and a database for evaluations of MaaS pilots has been set up (see Karlsson et al., 2019); and in New South Wales, TfNSW has established a research hub that, among other things, aims to catalyze research on MaaS developments (Study 4).

Research has been central in MaaS developments thus far. The evaluation of the UbiGo pilot (e.g. Sochor et al., 2015b; 2016), which established the notion that MaaS can drive travel behavior change, and Sonia Heikkilä's master thesis (2014) that played a considerable role in getting actors excited over MaaS, are perhaps the best examples of influential MaaS research. Still, many other publicly funded research activities have shaped MaaS developments too. In particular, the findings from the empirical studies in Sweden (Studies 1, 3 and 5) illustrate that much MaaS research in Sweden has been tightly coupled with ongoing MaaS developments[3]. This has paved the way for applied research on the prevalent practical issues the public sector faces, and for a significant knowledge transfer from research to policymaking. For example, beyond evaluating and disseminating the outcomes from the UbiGo pilot, researchers were also involved in designing the service and the pilot, drawing on previous experiences of setting up user-centric travel behavior experiments; the meet-ups associated with the Swedish national roadmap for MaaS developments were based on research insights regarding the vital role of informal meetings in Finnish MaaS developments; and PTA-VG's contract for third-party resale of tickets was partly inspired by theories on business model

innovation and its potential role in sustainability transitions. Furthermore, international transport conferences and research projects have contributed to knowledge transfer from international MaaS research and developments to Swedish MaaS policymaking, and cross-fertilization across the MaaS developments in the Nordic countries. Nevertheless, MaaS research has thus far not been able to deliver on policymakers' most candidly and frequently expressed need, namely empirical evidence on the societal effects of MaaS developments (see Section 1.3).

7.5 Answering Research Question Three

RQ3a: What have public sector actors done in relation to MaaS developments?

The results of the empirical studies show that public sector actors have done many things that have intentionally or unintentionally influenced MaaS developments. The undertaken public sector activities are summarized in Table 3 (on pages 76-77), while the public sector governance approaches to MaaS are summed up study by study hereafter[4].

In Sweden (Studies 1, 3 and 5), the three largest regional PTAs and their co-owned development company, Samtrafiken AB – together with the Swedish Innovation Agency and the Swedish Energy Agency – have thus far been the public sector actors most actively involved in MaaS developments. The national government has only recently begun to take an interest in the issue, while the role of municipalities still is marginal. The overall public sector approach has mostly encompassed reflexive activities aimed at understanding what conditions MaaS developments require and what MaaS could lead to for public sector actors and for society, as well as tactical activities aimed at adjusting strategies and infrastructures based on these insights. A shared, long-term vision for MaaS has been missing. The public sector approach has instead had a strong focus on the growth goals for public transport, which aim at incrementally improving the sustainability of personal mobility. As illustrated by PTA-VG, the leading view within the public sector of how the emerging MaaS value chain should be organized has evolved between 2016 and 2019: the procurement process (Study 1) was based on a hands-on model in which the PTAs control the MaaS Integrator and MaaS Operator roles via procurement, the attempt to introduce a national MaaS Integrator (Study 3) was based on a model in which PTAs have control over the MaaS Integrator role but leave the MaaS Operator role to the private sector, and the ongoing operational field test of EC2B (Study 5) is part of preparations for a model in which the private sector adopts both the MaaS Integrator and MaaS Operator roles.

In Finland (Study 2), MaaS developments have been tightly coupled with the deregulation and reform of personal mobility. This regulatory reform advocates an increasingly hands-off role for the public sector in general. In relation to MaaS, it implies that the dominating view has been that the public sector should adopt neither the MaaS Integrator role, nor the MaaS Operator role. The national government has (via LVM) had a front-seat role in MaaS developments. LVM, in partnership with other public sector actors at the

national level, and supported by a strong group of MaaS champions, has gone beyond the reform of the regulatory environment for personal mobility (strategic level), and also co-created several collaboration forums at the tactical level and funded operational experimentation. All in all, LVM has been a strong and vocal advocate for market-oriented MaaS developments. This has pushed Finnish PTAs into taking more reactive roles in relation to MaaS. To comply with the new regulations, PTAs have developed (or are currently developing) digital interfaces and contracts for third-party resale of their tickets, which has enabled MaaS experimentation. In particular, HSL was quick to do so, and has moreover tried to spur MaaS experimentation through a MaaS-related innovation challenge.

In New South Wales (Study 4), MaaS developments were not as advanced as in Sweden and Finland as MaaS had not yet become a significant topic of discussion. Still, in recent years, TfSNW has done a lot of work that might facilitate MaaS developments. Alongside other state-level transport authorities, it has arguably been the most active public sector actor in Australian MaaS developments. TfSNW has started to reform transport regulation in New South Wales towards being less descriptive regarding how mobility services should be operated. This was thought to make room for new integrative solutions to personal mobility problems. Driven by an ambition to deploy technologies to make personal mobility more modern and more effective, TfNSW has also, via a collaborative process, set up a 40-year vision for transport to guide its action plans, technology investments, and collaboration programs at the tactical level as well as its investments in operational experimentations. In the interviews, TfNSW employees interchangeably defined these activities as *no-regrets investments* and *puzzle pieces to MaaS*, which imply that they were judged to be components that pave the way for MaaS developments, as well as justifiable irrespective of how MaaS developments unfold.

RQ3b: How have these activities shaped MaaS developments?

The public sector activities, as evidenced in the empirical studies, have shaped MaaS developments in many ways. They have in particular produced tactical-level changes within and beyond the public sector, which in turn could pave the way for MaaS developments. For example, both public and private mobility service providers have accelerated their development, standardization, and opening of application programming interfaces for data and tickets, which enable the technical integration that MaaS requires. In contrast, the public sector approaches have not facilitated much concrete operational action, as the number of MaaS pilots or operations thus far is fairly small across the board. Consequently, none of the observed public sector governance approaches can be characterized as successful in producing tangible results yet (cf. the thesis' aim of devising a better understanding of how public sector actors can facilitate action in the early phases of MaaS development while also ensuring that MaaS contributes to a transition towards more sustainable personal mobility systems).

In Sweden, the general perception among the respondents was that public sector actors want to facilitate MaaS developments, but are hindered to do so efficiently due to organizational inertia and lacking experience with collaborative innovation, as well as by protectionism and by performance metrics that favor prevailing practices. Accordingly, the overall public sector approach was understood to cater for MaaS developments, although at a slower pace and to a lesser extent compared to what MaaS roadmaps and strategies indicated. The public sector approach was moreover perceived to favor MaaS developments that aim at incrementally changing personal mobility (in contrast to disrupting it), and to support exploration of opportunities related to MaaS (e.g. MaaS research and pilots) but not the exploitation of them (e.g. commercial developments and long-term MaaS collaborations). In terms of operational action, Sweden has no continually operating MaaS service yet, but the number of MaaS pilots is growing steadily.

In Finland, many respondents viewed the overall public sector approach as contemporary, brave, and conducive for MaaS developments. In particular, LVM was hailed as a MaaS champion that has gone out of its way to push for MaaS developments. Still, others perceived the public sector approach as hostile towards incumbent actors (and transport workers such as taxi drivers) and skewed towards paving the way for new entrants and eye-catching technology innovations rather than supporting the Finnish personal mobility system and the Finnish population as a whole. The active and front-seat role of the national government, and the links to the ongoing attempts to reform transport, have favored a revolutionary approach that aims to transform the Finnish personal mobility system from an old-fashioned cost burden to a technology-powered growth opportunity. The public sector activities have thus far created a lot of buzz around MaaS, both within and outside Finland. In terms of operational action, Finland has hosted several MaaS pilots, but Whim is thus far the only continuous MaaS operation.

In New South Wales, TfNSW taking the front-seat role was just part of the ordinary course of business, as state-level authorities have strong positions in Australia in general. This was perceived to give TfNSW a large action space to influence MaaS developments, although respondents noted that it is thus far unclear how TfNSW envisions the organization of MaaS operations. So, while some respondents described TfNSW's approach to MaaS as innovation-oriented, explorative, and step-by-step, others described it as defensive, protective, and disorganized. The strong focus on technology was moreover both praised and criticized, internally as well as externally. In terms of operational action, this approach has not produced much MaaS experimentation. Five MaaS-related pilots, funded and supervised by TfNSW, have been announced, but are yet to commence. Simultaneously, a research-oriented MaaS pilot has been implemented in Sydney during 2019-2020, although without direct involvement from the public sector (apart from research funding provided by the federal government).

Table 3. Public sector activities perceived to shape MaaS developments

Level	Hands-on activities	Hands-off activities
Strategic	Long-term visions Collaborative visioning in which the public sector oversees processes and controls decision-making (e.g. the Future Transport 2056 strategy in Study 4 and the Transport Revolution Program in Study 2).	
Tactical	Internal strategies Developing and disseminating internal MaaS strategies (e.g. Region Stockholm's MaaS strategy in Study 3 and PTA-VG's MaaS missions in Studies 1, 3 and 5). Orders Ordering external actors to deliver specified MaaS services or MaaS-related products (e.g. the procurement process in Study 1 and the multi-modal public transport contracts in Study 4). Technology developments Digitalizing public transport planning and payment systems (e.g. the public transport app in Study 1 and the digitalization of community transport in Study 4). Developing digital infrastructure for sharing public transport data and tickets (e.g. the hub for open data in Study 4 and the attempt to develop a national intermediary for data and ticketing in Study 3). Harmonizing data and ticketing frameworks and interfaces (e.g. the standardization work in Study 3 and the payment framework in Study 4).	Action plans Requesting and funding external actors to develop MaaS action plans (e.g. the national roadmap for MaaS in Study 3). Regulatory developments Reforming transport regulation to open degrees of freedom for external innovation (e.g. the Transport Code reform in Study 2 and the Point-to-Point reform in Study 4). Signing contracts for resale of public transport tickets to enable external MaaS developments (e.g. HSL's contract in Study 2 and PTA-VG's contracts in Study 5). Launching platforms for collaborative policy experimentation (e.g. the Regulatory Sandbox Initiative in Study 4). Collaboration forums (also hands-on) Launching and participating in formal and informal collaboration forums (e.g. Thursday night MaaS discussions in Study 2 and the Digital Accelerator Program in Study 4).
Operational	Experimentation leadership Leading and managing MaaS-related experiments (e.g. the TfNSW's MaaS pilots in Study 4 and the parking app pilot in Study 5).	Experimentation funding Funding and participating in externally led MaaS experimentation (e.g. the UbiGo pilot in Study 1 and the EC2B pilot in Study 5).

Level	Hands-on activities	Hands-off activities
Reflexive	Investigations Investigating conditions for MaaS developments and potential future pathways (e.g. scenarios for MaaS developments in Study 1 and legal investigations into PTAs' roles in MaaS in Study 3). Monitoring of developments Monitoring MaaS and related developments (e.g. the follow-up of the impacts of the Transport Code in Study 2).	Research funding Funding and participating in research projects (e.g. MaaSiFiE in study 2, Mistra SAMS in study 3, and the doctoral research project culminating in this thesis). Research infrastructures Funding of infrastructures for MaaS research and knowledge generation (e.g. the framework for MaaS pilot evaluations in Study 3 and the research hub in study 4).

1. This forum is sometimes called the New Transport Policy Club (e.g. Kanger & Kivimaa, 2019; Ovaska, 2017).
2. The national government has moreover ordered the Swedish Transport Administration to investigate if it is possible to develop a national *access point* that enables third-parties to resell mobility service offerings (Regeringskansliet, 2019). This investigation and the investigation into a national ticketing system for public transport (Regeringskansliet, 2020b) both have similarities with the proposed national MaaS Integrator function analyzed in Study 3 (i.e. *Mobilitetstorget*).
3. In contrast, this research has not evidenced as strong structural links between MaaS research and MaaS policymaking in Finland and New South Wales as in Sweden. However, this observation may be, at least in part, due to the researcher's higher level of engagement and insight in Swedish MaaS developments.
4. Overall governance approach here refers to the sum of public sector activities that influence MaaS developments (intentionally and unintentionally). In other words, the governance approaches to MaaS are manifested in the undertaken public sector activities described throughout this chapter.

PART 4 IMPLICATIONS & REFLECTIONS

CHAPTER 8
Implications for Governance

Returning to the thesis's primary aim, and shifting the perspective from descriptive to prescriptive, this chapter proposes implications for public sector actors that wish to facilitate and steer MaaS developments, based on a comparison of the findings presented in Chapters 5 through 7 with the existing literature on MaaS, sustainability transitions, and collaborative innovation. These implications are presented as governance principles (i.e. activities deemed important irrespective of the public sector's roles in MaaS) and governance pathways (i.e. activities that are related to distinct public sector roles).

8.1 Principles

Departing from the Transition Management Framework, this section proposes three principal activities: establish a long-term vision for MaaS, draft an agenda for MaaS developments, and support MaaS experimentation. How to perform these activities is further specified through 15 sub-activities. Importantly, these activities should be the subject of critical analyzes, as a means to revisit and refine governance approaches as MaaS evolves (cf. the cyclical process of transition management in Loorbach, 2010).

8.1.1 Establish a Long-Term Vision for Mobility-as-a-Service

The vision for MaaS, as formulated in the academic and grey literature, can be summarized as to see personal mobility systems as cooperative entities where actors are interconnected and provide mobility services that reflect users' specialized needs (Hietanen, 2014; Romanyuk, 2018). A transformation of current personal mobility systems towards this state has, by many MaaS researchers, been assumed to lead to improvements for users and businesses as well as for society. Frequently voiced predictions include that MaaS will help users identify and choose the optimal means of making journeys and thus make travelling more convenient and efficient (Goulding & Kamargianni, 2018); bring new business opportunities for mobility service providers and supporting actors such as technology providers and insurance companies (Kamargianni & Matyas, 2017);

and contribute to more sustainable personal mobility systems by reducing private car ownership and causing a modal shift from cars to walking, bicycling, and public transport use (Kerttu et al., 2017).

Despite these assertions, the respondents in Sweden did not share either a common vision or an agenda for MaaS developments. There was a lack of consensus as to the respondents' understanding of what the long-term objective of MaaS developments were, as well as regarding what needs to be done to achieve the desired state and how prioritized MaaS developments were contra other investments. Consequently, it was difficult to discuss what MaaS success would look like, when it could be expected, and who should lead the development and diffusion processes. In contrast, the tone was different in Finland. Although not everyone agreed with the chosen strategy in Finland, involved actors were for the most part aware of the vision and underpinning rationale of the leading public sector actors. This pressured other actors, such as HSL, to act (Audouin & Finger, 2018). It also made it easier to coordinate activities across spatial scales, sectors, and organizations, and paved the way for private investments in Finnish MaaS developments.

Hence, an important task for the public sector is to *(i) set up and communicate a strong and inspiring long-term vision for MaaS that addresses sustainability goals*. The vision (possibly supported by measurable impact targets) should signal public sector commitment and be concrete enough to be understandable, but still allow for individual interpretations (cf. Torfing, 2016); actors should be able to develop their own future images that fit the common MaaS vision as well as their individual strategies. It is also important to align the vision with plans from non-transport policy sectors such as land-use, regional growth, and public health (cf. policy integration in Stead & Meijers, 2009).

To accomplish this, it is critical that the *right* actors are involved in formulating the vision. No actor can manage a transition on its own. Instead, due to the severity and long-term nature of sustainability challenges, sustainability transitions are contingent on involvement from multiple and diverse actors (Wittmayer & Loorbach, 2016). The empirical studies illustrated that this is also the case for MaaS, as it is an intrinsically collaborative concept that stretches over multiple sectors and geographies. Therefore the process of developing a long-term vision for MaaS should preferably be carried out collaboratively among public, private, and social sector actors that have the capability to influence different parts of personal mobility systems. For this type of work, Loorbach (2010) suggested "a small network of frontrunners with different backgrounds" (p. 173). He recognized that some representation from the existing regime is necessary but held that the aim is not that the incumbents come together, but that "innovative individuals who can operate more or less autonomously" (p. 174) are involved. However, decisions about what actors are included and excluded are delicate and of a political nature. The actors that are included will be able to influence the outcomes of and the rhetoric surrounding MaaS developments, which other groups of actors would likely have valued and prioritized differently (cf. Lyons, 2018; Torfing, 2016).

Moreover, the empirical studies showed that the involvement of strong incumbents is crucial for the operationalization of MaaS visions, despite these actors vested interests in the present state of affairs. Many public organizations, including PTAs, were not invited to the major envisioning processes in Finland. This seemed to fuel a reluctance to adopt the MaaS concept (cf. Haavisto, 2019)[1]. Since the modal share for public transport is high in Finland, this reluctance created major problems for MaaS developments. According to many of the respondents in Finland, the national government's attempts to force PTAs to enable and participate in MaaS developments have moreover fallen short. Regulatory reform is a slow process, and regulations can only establish a minimum level of commitment, which is not enough to create a vibrant innovation milieu. Thus, rather than drafting the vision within an enclosed group and then forcing it upon others, the public sector should *(ii) involve a broad set of actors in MaaS visioning and long-term goal formulation activities*. To facilitate anchoring, commitment and aligned policymaking, this involvement should encompass strategic and operational actors that have the mandate and discretion to govern MaaS within and beyond their own organizations. For example, municipalities have a key role in aligning MaaS visions with local processes (Fenton et al., 2020), but have been reluctant to enter MaaS collaborations thus far (Polydoropoulou et al., 2020).

Visioning and goal formulation activities can be perceived as cumbersome and time consuming, especially the problem definition task. Many frontrunners see only certain aspects of a sustainability problem or have difficulties with seeing the bigger picture (Loorbach & Rotmans, 2010). Providing precise and agreed-upon problem definitions is therefore difficult, and the attempts to get a handle on problems are ongoing learning processes (Torfing, 2016). In the empirical studies, it was evident that the involved actors struggled with understanding other actors' perspectives and appreciating the challenges others faced. Generally, there was a large cognitive distance between actors stemming from different sectors, and operating at different spatial scales and time frames (cf. Munksgaard et al., 2012). MaaS-related terms were also understood and used in contradictory ways, which hampered knowledge exchange. So, a good start for a collaborative vision formulation processes could be to *(iii) establish a shared language about MaaS and a shared understanding of personal mobility systems*. For instance, what is MaaS, how is MaaS different from current practices, and which problems can MaaS resolve? Moreover, since public-private collaborations are subject to many motivation and coordination challenges, public sector leadership is vital (cf. Torfing, 2016), as well as a clear division of labor among participating actors (cf. Mazzucato, 2018). These issues are further discussed in next section.

8.1.2 Draft an Agenda for Mobility-as-a-Service Developments

MaaS is at a first glance an intuitive concept. Sampo Hietanen, the co-founder and current CEO of MaaS Global Oy (the MaaS Operator behind Whim), has in many public talks on MaaS stated that the average person on the street *gets* MaaS. The only thing the

person on the street does not get is, according to Hietanen, why MaaS does not exist yet. However, MaaS developments are not as straightforward as they may first seem, neither for the person on the street, nor for the involved actors. For example, comparing the timeline of the Swedish MaaS roadmap with the MaaS reality in Sweden illustrates how the complexity of MaaS developments has been underestimated. One of the roadmap's performance goals was that at least three MaaS services should be up and running in Sweden by the end of 2018 (KOMPIS, 2017). This was not the case; no MaaS service was in operation at that point.

The analysis of the empirical studies revealed several types of institutional barriers. Consequently, several types of innovation are likely needed to make MaaS happen. The tactical level of the Transition Management Framework centers on creating and prioritizing an agenda of innovation activities that address institutional barriers and transform the current state to the envisioned state. Such agendas are crucial for operationalizing visions, and for coordinating actions (Loorbach, 2010). MaaS-related innovation agendas were present in both Sweden and New South Wales. While TfNSW's roadmap for technology developments explicitly focused on developing and deploying novel technologies (see TfNSW, 2016b), the national MaaS roadmap in Sweden took a broader approach that proposed the exploration of new business agreements as well as policy innovation and the development of tools for structured impact analyses (see KOMPIS, 2017). Still, based on the diversity of the identified institutional barriers, and on the slow-moving, convoluted MaaS developments, the experience to date suggests that agendas for MaaS developments need to have even broader approaches to efficiently push MaaS developments. In other words, the public sector should *(iv) take lead in developing a holistic agenda for the development, diffusion, and use of MaaS*. This agenda can then be used to guide, coordinate, and prioritize MaaS-related activities at the tactical and operational levels. While targeting the long-term vision (and its impact targets), the agenda should also include intermediate goals that focus on learning (cf. Torfing, 2016) rather than on achieving societal effects in the short to medium term (further discussed in Section 8.1.3). Three areas that have been overlooked in current agendas for MaaS developments, but that should be included according to the evidence from the empirical studies, are described next: inter-organizational collaboration, user involvement, and service systems.

Inter-organizational collaboration: The knowledge regarding how to organize MaaS developments, and what MaaS could lead to, is still limited. Accordingly, the level of uncertainty is high. This was especially apparent in Study 1, where PTA-VG tried to procure a MaaS service for Västra Götaland. On one side of the negotiation table, PTA-VG only had experience from the small-scale and short UbiGo pilot (which operated under pilot-specific policy conditions). Consequently, PTA-VG struggled with defining what type of service it wanted, what assets it was willing and able to provide to the MaaS Operator, and how success would be measured. On the other side of the table, the potential bidders often had even less experience with MaaS and struggled to explain

how they would take on the task, and what a viable business model could look like. The traditional procurement model that PTA-VG had chosen was mismatched with this situation, in which the task was new for the procurer (PTA-VG) and the supply environment was uncertain (cf. Bakker et al., 2006). Rather, when the level of uncertainty is high among both procurers and bidders, adhocracy procurement structures characterized by collaboration throughout the procurement process, much flexibility, shared risks, few formal rules, and much emphasis on interpersonal relations are more fitting (ibid.). One example of such an approach is the pre-commercial procurement process, which supports several consortiums in designing, prototyping, and field-testing solutions prior to choosing one solution to commercialize (cf. Edler & Georghiou, 2007).

Thus, the public sector should *(v) implement new models and tools for long-term public-private innovation collaborations*. In the development and diffusion phases, these models should facilitate practical experience building through experimentation and iterative and collective decision-making structures, as well as mutual learning by establishing and supporting collaborative environments that focus on knowledge sharing, constructive problematization, and collective action (cf. the transition arena in Loorbach, 2010). To create such environments, Torfing (2016) advocated a balance between empowerment and disempowerment to ensure that power asymmetries are not so large that they prevent collaboration, as well as a balance between institutionalization and deinstitutionalization to enable stable and sustained but sufficiently flexible interactions. He furthermore held trust-building exercises, incentives for collaboration, and process management as key features for mobilizing actors and facilitating collaboration (ibid.). Two examples to take inspiration from in the empirical studies are the think tank on future mobility in Finland, which boosted the formation of a strong informal network of MaaS champions, and the Digital Accelerator Program in New South Wales, which provided a structured but open-minded milieu for collaborative experimentation.

To enable MaaS diffusion, it is key to formulate a plan for how to bridge the gap between time-limited pilots and continuous operations as well as for how to organize and fund marketing and user acquisition. While the former issue requires formal control mechanisms (e.g. MaaS partnership contracts, see Meurs et al., 2020) and potentially changes to public procurement regulations (or the interpretation of them), the latter issue is related to the much-discussed topic of business models for MaaS (e.g. Aapaoja et al., 2017; Polydoropoulou et al., 2020; Sarasini & Linder, 2018; Sarasini et al., 2017). The evidence from the empirical studies indicated that building on existing user relationships and initially targeting niche user groups could be feasible tactics (cf. Stummer et al., 2018). Marketing messages should moreover preferably highlight both extrinsic and intrinsic benefits since psychological needs play a crucial role in MaaS acceptance (Schikofsky et al., 2020). In the use phase, it is vital that the inter-organizational collaboration models facilitate data sharing and shared ownership of user relationships, since the empirical studies illustrated that losing control over data and user relations are prominent worries among mobility service providers.

New models for long-term MaaS collaborations require public sector actors in general and PTAs in particular to *(vi) develop internal strategies for management of collaborative innovation projects*. For example, PTA-VG was deemed well suited for the traditional task of operating and maintaining the regional public transport system but as less well suited to drive and participate in explorative and collaborative innovation projects. Their indecisiveness regarding how to organize the work that followed the UbiGo pilot contributed to the inactivity, which frustrated other actors involved in MaaS developments. Here, more clearly defined internal innovation processes and innovation managers that have the competence and mandate to manage collaborative innovation processes could have been beneficial (cf. Chesbrough & Crowther, 2006; Sørensen & Torfing, 2012). This includes strategies for risk management (further discussed in Section 8.1.3). Another issue that PTA-VG was criticized for was its low prioritization of external innovation projects. Internal projects' needs were ranked as more urgent and significant, and thus prioritized higher. This made it difficult for external actors to plan their innovation processes. PTA-VG's poor communication regarding its internal planning also contributed to this difficulty[2]. Additionally, the studied operational field test (Study 5) illustrated that key MaaS enablers include that PTAs clearly disseminate their long-term MaaS strategies and (in a scenario of third-party MaaS Operators) develop technical infrastructures, collaboration routines, and contracts that support third-party resale of public transport tickets.

User involvement: MaaS has frequently been argued to be a user-centric concept (e.g. Jittrapirom et al., 2017; Kamargianni & Matyas, 2017; Polydoropoulou et al., 2020). Still, the elements of user involvement in MaaS developments seem to be limited (also noted by Kriukelyte, 2018). When users have been involved, they have primarily been consulted as evaluators rather than participated in creative activities or decision-making. For instance, MaaS Global Oy has regularly utilized user feedback to evaluate Whim, and prospective users were invited to ideation workshops when the EC2B service was designed, but there is not much indication (in the publicly available information) that users have taken part in critical design decisions in any of the cases. Hence, the studied MaaS developments cannot be described as democratized innovation systems in which users are important co-creating partners (cf. Sanders & Stappers, 2008; von Hippel, 2005). Notably, there is moreover no proof of any general public demand for MaaS across the empirical studies, and in Sweden, a national questionnaire found that 80% of the population had never heard of MaaS or related terms (Sochor et al., 2018b).

Users are increasingly recognized as important actors in sustainability transitions (Randelli & Rocchi, 2017). Since users' adoption decisions will ultimately decide whether MaaS services are successful or not, MaaS developments must center on user needs in one way or another (Lyons et al., 2020). One tactic in this regard can be to involve a diverse group of users to participate in co-creation and decision-making in all the phases of the innovation process (cf. Heiskanen et al., 2007)[3]. However, such activities require access to capable and willing users. It has moreover proven difficult to represent the

complexity of MaaS through traditional mock-ups, prototypes, and descriptions. This makes it hard for potential users to imagine and contextualize what MaaS would imply for them. Hence, new design methods, such as metaphors and enactment techniques, might be needed to support MaaS co-creation processes (cf. Strömberg et al., 2020). Furthermore, what is best for (and thus requested by) users is not necessarily what is best for society (Sochor et al., 2015b). For instance, enhanced door-to-door mobility could have negative effects on public health, and the MaaS ideal of unfettered mobility freedom is at odds with the limitations of finite transport infrastructures (Pangbourne et al., 2018). Hence, a deep understanding of user needs and of societal needs is necessary to develop sustainable and enduring MaaS services. Here, a key role for the public sector is to *(vii) ensure that MaaS developments are both user-centric and society-centric*.

The MaaS services tested in the empirical studies displayed recurring entry barriers for use, such as access to smartphones, bank cards, driver's licenses, and urban mobility services. Furthermore, the experience with Whim in Helsinki suggested that the diffusion of Whim is primarily driven by urban-dwelling millennials (Hartikainen et al., 2019), and the EC2B operation in Gothenburg targeted an exclusive group of well-off urban dwellers. These limitations imply that large parts of the population are at risk of not benefiting from MaaS developments and indicate that MaaS in its current forms should be considered as niche services rather than as targeting mass audiences. Again, it should be noted that MaaS developments are in their infancy; thus, one should be careful with judgments on whether MaaS is inclusive or not. Still, a key task for the public sector is to *(viii) closely monitor which user groups have benefited from MaaS developments (and which have not)*[4]. Then, going forward, the scope of MaaS can either be broadened, or alternatively, MaaS can be accepted as a niche solution which, to ensure an equitable allocation of public resources, must be complemented with other investments that target those persons who do not benefit from MaaS developments.

Service systems: MaaS policy recommendations have thus far focused on topics directly related to the development of MaaS services, such as multiple types of MaaS business models, cost-effective deployment of small-scale MaaS pilots, and robust cyber security and data management facilities (MaaS Alliance, 2017). In contrast, the empirical studies revealed that institutional barriers to MaaS diffusion are both directly and indirectly related to MaaS. For example, the adoption of EC2B was coupled with the introduction of new mobility services, a (purposefully) decreased attractiveness of private car ownership and use, and the development of local transport infrastructures supporting active mobility. However, the adoption was also impeded by the shortcomings of the included mobility services, a culture of car ownership, and that transport infrastructures in Gothenburg do not sufficiently support active mobility. In other words, MaaS developments are intertwined with broader developments within personal mobility systems. In particular, this indicates that MaaS is caught between the service systems for mobility services and active mobility and the private car system, and contingent upon transforming them all (cf. Parkhurst et al., 2012). This has at least three implications.

Firstly, MaaS developments are reliant on developments within the service systems that are envisioned to feed into MaaS, many of which currently play marginal roles in personal mobility systems (cf. Brundell-Freij et al., 2019). Consequently, public sector actors should *(ix) push for the diffusion and use of mobility services*. More specifically, Li and Voege (2017) proposed that a basic condition for MaaS developments is the availability of a wide range of mobility services which have digital infrastructures for ticketing and payment, provide real-time data to third parties, and allow third parties to resell their services (see also Aaltonen, 2017). The empirical studies echoed this proposition; MaaS aims to integrate multiple types of mobility services, but many of these are typically only available in large cities (cf. Rotaris & Danielis, 2018). Hence, the diffusion of MaaS into less (obviously) profitable markets, such as sparsely populated areas (e.g. Eckhardt et al., 2018; Mulley et al., 2018), may require MaaS to be organized in an entirely different fashion and that the public sector funds the provision of mobility services to a greater extent. Since many service systems are not fully digitalized yet, public sector actors that want to facilitate MaaS developments should also *(x) assist the rollout of harmonized digital infrastructures and integration procedures across mobility service systems*.

Secondly, although the expectations of the impacts of MaaS diverged, the respondents agreed on a few things. Notably, they almost unanimously identified public transport and other mobility services as the winners from a diffusion of MaaS, and the private car as the main loser. The structures reinforcing car ownership and use were also among the most frequently reported barriers to MaaS diffusion. MaaS has thus far been marketed as a service that can compete with car ownership by offering users an improved level of freedom through greater choice. For example, Whim has been interchangeably described as *better than owning a car* and *the end of private car ownership*. Consequently, MaaS' appeal among potential users, as well as its legitimacy among operational and strategic actors involved in MaaS developments, seem to largely rest upon MaaS' relative attractiveness compared to owning and using private cars. Accordingly, public sector actors should *(xi) carry out policies aimed at speeding up the decline of the private car regime* (cf. the exnovation strategy in Clausen & Fichter, 2019). The empirical analysis identified a potentially mutually reinforcing relationship between the introduction of MaaS and the implementation of policies that reduce car use; the access to EC2B and its components made it easier to implement a zero residential parking policy, while the lack of access to on-site residential parking stimulated the adoption of EC2B. However, such policies are politically delicate to implement, and in general, a reluctance to seriously consider how to unsettle and unlock established regimes has been observed (Smith et al., 2010). Among other things, there is a prevalent worry among many politicians that regime change will have severe effects on national economic output, and thus on jobs and tax revenues (Foxon, 2017). Accordingly, redeployment of human capital and knowledge through viable exit alternatives for incumbent firms and their employees have been identified as important enablers of sustainability transitions (Andersen & Gulbrandsen, 2018). In fact, incumbents can act as drivers of sustainability transitions if they see a potential to leverage their resources in the emerging socio-technical regime (Steen & Weaver, 2017).

Thirdly, active mobility that is not based on mobility services, such as walking and cycling with privately owned bicycles, was not a central discussion topic among respondents. Rather, the potential impacts of a diffusion of MaaS on these modes were dealt with indirectly and vaguely. This approach was mirrored in many MaaS-related strategy documents. For instance, the national MaaS roadmap in Sweden stated an aim of improving "the potential to select sustainable transport with shared resources as well as walking and cycling" (KOMPIS, 2017, p. 5). Still, while the roadmap outlined multiple strategies for how to improve the attractiveness of public transport and other mobility services, none of the proposed activities targeted the links between MaaS and active mobility. To ensure that MaaS is aligned with the goal of increasing walking and bicycling, public sector actors should *(xii) formulate specific strategies on how MaaS is to promote both mobility services and active mobility*.

8.1.3 Support Mobility-as-a-Service Experimentation

The analysis of how actors involved in MaaS developments anticipated that MaaS will influence personal mobility systems revealed optimistic (MaaS believers), skeptic (MaaS skeptics), and pessimistic (MaaS opponents) basic rationales. Comparable rationales are present in the scientific literature on MaaS. For instance, many MaaS studies have departed from the notion that MaaS is a personalized and intelligent concept that will offer consumers seamless and convenient door-to-door experiences and thus provide a viable alternative to private car ownership and use (e.g. Goulding & Kamargianni, 2018; Kamargianni & Matyas, 2017). As such, these studies assumed at the outset that MaaS will be better for both users and society compared to existing alternatives. In contrast, Pangbourne et al. (2020) argued that there is strong potential for increased mobility among MaaS users, which "runs counter to the need to reduce overall automotive movement to prevent or reduce undesired effects [of personal mobility systems] and does not address the needs of those experiencing transport poverty" (p. 47). Similarly, Docherty et al. (2018) concluded that smart mobility concepts such as MaaS can exacerbate rather than ameliorate the wider social and environmental problems of personal mobility systems if not strictly governed by the public sector.

Of note though is that none of these propositions are backed by any extensive empirical evidence. Rather, the empirical evidence on the impacts of MaaS diffusions is still limited (Durand et al., 2018; Hensher et al., 2020; Karlsson et al., 2017). To advance from speculation-based to (more) proof-based discourses, and to paint a fuller picture of how to realize MaaS, who MaaS is for, and what MaaS diffusion leads to under various conditions and contexts, empirical evidence is needed. In turn, this requires more as well as longer and increasingly diverse MaaS pilots and full-scale implementations, which are systematically evaluated (and the results disseminated). Beyond trialing distinct types of MaaS services, these experiments should also aim to generate knowledge regarding different forms of inter-organizational collaboration, as well as the effects of different institutional conditions (e.g. the effect of transport policy changes).

Two types of public sector activities are imperative for pushing MaaS-related experimentation and joint knowledge generation. Firstly, public sector actors need to *(xiii) take or share the economic risks of MaaS experimentation by (co-)funding pilots and operations*. Preparing, marketing, and operating MaaS pilots is associated with substantial costs, and since institutional barriers make continued operation unlikely after pilots (at least if public sector actors are involved), it is difficult to leverage the acquired user bases and brand recognition. Consequently, the attractiveness for private sector actors to invest in MaaS experimentation is quite low, especially if the public sector's long-term MaaS vision and strategies are unclear. However, in contrast to the common perception, public sector actors are often prepared to take larger innovation risks than private sector actors, and can often more readily absorb the costs of failure due to their large sizes and long-term plans (Mazzucato, 2015). Furthermore, since the prospects of continuing services after the pilot periods are low, there is also a risk of creating false expectations among participating users. This has ethical and reputational implications. Hence, a communication strategy that establishes a shared understanding of pilot goals and limitations among all actors (including potential users) prior to embarking on MaaS experimentation is important.

While, MaaS pilots are costly and uncertain endeavors, public sector investments can be motivated in part by more certain indirect benefits. For instance, the UbiGo pilot did not meet its stated goal of preparing the implementation of a MaaS service in Västra Götaland (LSP, 2014). Yet, for PTA-VG, the pilot generated insights into opportunities and challenges related to MaaS developments. Similar gains have been reported by other PTAs that have funded and participated in MaaS experimentation (e.g. Kesteloot, 2019).

Secondly, public sector actors need to *(xiv) set up internal institutional conditions that favor experimentation*. This includes formal structures, such as the organizational capacity to initiate and host collaborative innovation projects as well as informal practices such as a culture of embracing uncertainties and risks (cf. Lyons & Davidson, 2016; Torfing, 2016). Acknowledging, accepting and managing risks are central features for innovation performance (Osborne & Brown, 2011). Brown and Osborne (2013) proposed that current approaches to risk management within the public sector are mismatched with the complexity of innovation, and argued that risk governance, rather than risk minimization, is a more fitting tactic, especially when innovation processes address new needs and require new organizational skills. This type of approach includes a collaborative process in which involved actors agree on acceptable levels of risk (set alongside the expectations of potential benefits) and on mechanisms for evaluation and accountability. The empirical studies indicated that explicit short- and medium-term learning goals[5], and some leeway when it comes to performance within that period, are needed to counterbalance short-termism and to create a risk-prone culture. A focus on learning rather than performance might also mitigate the Hawthorne and learning-curve effects, i.e. that pilot results are either too positively or too negatively assessed (Mulgan & Albury, 2003).

Experimentation also requires action space, i.e. that new types of activities are possible, perceived, and considered (cf. Strömberg, 2015). In the case of MaaS, the empirical studies showed that the perceived action space of PTAs is limited by legal barriers and by the activities of the national governments and government agencies. A problem of separated planning responsibilities has also been brought forward in the existing literature on MaaS. MaaS promises to integrate multiple services systems but the planning responsibility for the different service systems is often held by seperate actors, which makes it difficult to coordinate action (Hensher, 2017). Wong et al. (2018) proposed that mode-agnostic mobility contracts can increase the action space of public transport operators. Similarly, the empirical studies in Sweden illustrated that the limited flexibility in what means PTAs can peruse to achieve policy objectives limits their willingness to engage in MaaS experimentation. To increase PTAs' perceived action spaces in relation to MaaS developments (and desire to experiment), the public sector should *(xv) adopt an enlarged understanding of public transport that encompasses more means of shared and active travelling* (see also Becker et al., 2020).

8.2 Pathways

Approaches to governing MaaS developments differed across the empirical studies. Among other things, the approaches varied by whether public sector actors primarily aimed to be directly involved in the practical innovation activities or not (i.e. hands-on or hands-off). Drawing on PTA-VG's procurement attempt, Paper A proposed three possible scenarios for MaaS developments: a *market-driven* scenario, which entailed that the MaaS Integrator and MaaS Operator roles would be absorbed by the private sector; a *public-controlled* scenario, which entailed that the public sector would adopt the MaaS Integrator and MaaS Operator roles; and a *public-private* scenario, which entailed that the public sector would absorb the MaaS Integrator role while the MaaS Operator role would remain open for private actors to adopt (see Figure 7).

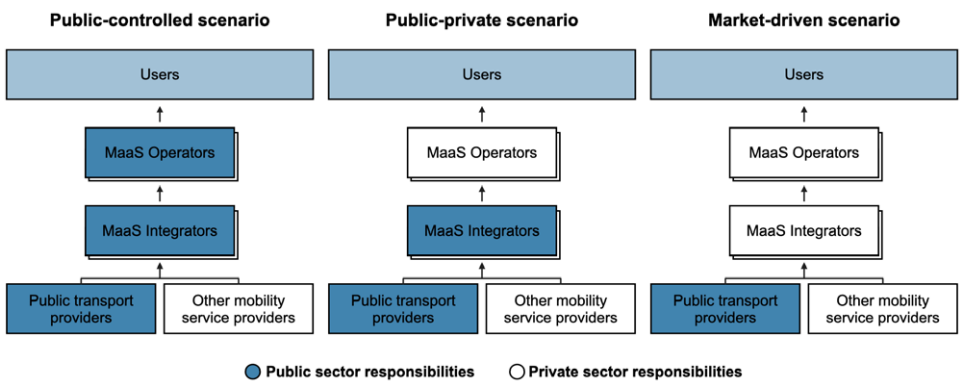

Figure 7. Three scenarios for MaaS developments, adopted from Paper A

This categorization has subsequently been used by researchers and practitioners to facilitate discussions on the pros and cons of different MaaS governance approaches (e.g. Narupiti, 2019). Numerous analogous and overlapping models for how the MaaS value chain can be organized have also been presented in strategy documents, consultancy reports, and conference papers (e.g. Arthur D. Little, 2014; Eckhardt et al., 2017; Holmberg et al., 2016; Kerttu et al., 2017; KPMG, 2017; Region Stockholm, 2016; Siemens, 2017; UITP, 2019). In addition to illustrating the different types of public sector involvement, these models recognize that MaaS value chains can be more or less open, and that the decision-making can be either centralized or decentralized (cf. Casey & Valovirta, 2016). In other words, a MaaS value chain can include either one or several MaaS Integrators as well as MaaS Operators, which can in turn have either small or large degrees of autonomy. Nevertheless, most of these models focus exclusively on the governance of the operational value chain (i.e. the use system) but ignore how strategic and operational tasks are distributed across public and private sectors during the development and diffusion phases (two notable exemptions to this rule are Hirschhorn et al. (2019) and Audouin and Finger (2019), which both drew on sustainability transitions and governance literatures to categorize how public sector actors have approached the governance of the early phases of MaaS developments thus far).

In contrast, models for collaborative innovation typically focus on public sector approaches to innovation development and diffusion. For example, Kronsell and Mukhtar-Landgren (2018) described four roles that municipalities typically take in relation to urban experimentation[6]: *promoting* by initiating, funding, and leading experiments; *partnering* by participating in experimentation partnerships in which actors are fairly autonomous and share leadership (cf. self-organizing inter-organizational networks in Rhodes, 1996), *enabling* by opening for, facilitating, and encouraging other actors to experiment (cf. governing through enabling in Bulkeley & Kern, 2006); and *taking a non-role* by primarily acting as a recipient of experimentation outcomes. The choice between these ideal roles is neither discrete, nor made in isolation. Rather, choices of governance approaches are fluid and influenced by contextual and situational factors (Wallsten et al., 2020).

To offer a more holistic understanding of how public sector actors (that want to facilitate and steer MaaS developments) can approach MaaS governance, this thesis combines these two perspectives into a framework for public sector MaaS governance pathways during the development, diffusion, and use phases (see Table 4). The framework departs from the three scenarios illustrated in Figure 7. It is moreover based on the notions that the systems for development, diffusion, and use can be separate, and that actors' roles can vary between them (cf. Malerba, 2002); a public sector actor can take several, simultaneous governance roles in each innovation phase, as well as change roles across MaaS innovation phases. As such, it provides a more comprehensive tool for understanding public-private dynamics in MaaS developments, as compared to extant MaaS governance models' focus on either the development and diffusion systems or the use system.

Table 4. Pathways for governing MaaS developments

Role	Development	Diffusion	Use
MaaS Promoter	Takes the lead in transforming MaaS visions and ideas into operational services	Acts as the lead customer for MaaS services and/or advertises MaaS services	Integrates mobility service data and tickets, and operates MaaS services
MaaS Partner	Participates in knowledge sharing forums and in MaaS experiments	Legitimizes MaaS services, supports marketing, and shares user insights and data	Mediates data and tickets from mobility service providers to MaaS services
MaaS Enabler	Opens for and funds MaaS experimentation and research	Promotes the diffusion of mobility services and/or digital interfaces	Feeds data and tickets for its own mobility services into MaaS services
Laissez-Faire	Monitors MaaS development processes while continuing business as usual		

The *MaaS Promoter* role entails using hands-on governance activities to manage and participate in MaaS developments. MaaS Promoters are thus directly involved in executing tactical and operational innovation activities. In the development phase, this means mobilizing resources to lead and coordinate the development of MaaS services and components. For example, Samtrafiken AB's initiative to develop technical standards for public transport data and ticketing can be understood as taking a MaaS Promoter role in the development phase.

In the diffusion phase, MaaS Promoters use their capabilities and capacities to accelerate the uptake of MaaS. This could include incentivizing their employees to act as lead customers, or co-funding MaaS marketing and user acquisition. In the use phase, a MaaS Promoter role entails taking on the MaaS Integrator and MaaS Operator roles, either directly or via contract (cf. the public-controlled scenario in Figure 7). The federally owned public transport company in Berlin (Berliner Verkehrsbetriebe, BVG) has arguably acted as a MaaS Promoter in the diffusion and use phases. In 2019, BVG set up a new unit that focuses on MaaS and mobility hubs, and which is managed as an external start-up company (Intelligent Transport, 2019). Empowered by a private technology provider, and in partnership with private mobility service providers, this unit now markets and operates the MaaS service, Jelbi, in Berlin.

The *MaaS Partner* role entails using a mix of hands-on and hand-off governance activities to build collaboration networks, and to support, participate in, and influence private sector led innovation activities. Beyond being central in setting the underpinning vision and agenda for MaaS, MaaS Partners focus on setting up and participating in knowledge

sharing forums and MaaS experiments during the development phase. By co-founding and partaking in numerous MaaS forums (e.g. MaaS Alliance), and by encouraging and supporting MaaS experimentation in Helsinki (via its innovation company), the City of Helsinki has taken a MaaS Partner role thus far.

In the diffusion phase, MaaS Partners can contribute to MaaS uptake by sharing user insights with MaaS Operators, and by legitimizing their MaaS services. For instance, the PTA in the Stockholm region (Region Stockholm) has supported the diffusion of Nobina's MaaS service, Travis, by informing other PTAs of its existence and by using it as an inspirational example (however, Region Stockholm has not marketed Travis to potential users). In the use phase, MaaS Partners feed data and tickets from the mobility services they operate to external MaaS Operators. In addition, MaaS Partners mediate data and tickets from other mobility service providers by taking on the MaaS Integrator role (cf. the public-private scenario in Figure 7). Samtrafiken AB's preparation for the launch and operation of a national MaaS Integrator was indicative for trying to take on a MaaS Partner role during the use phase.

The *MaaS Enabler* role entails using hands-off instruments to create conducive conditions for the development, diffusion, and use of MaaS services that are managed by external actors (cf. the network design and network framing tools in Sørensen & Torfing, 2009). In the development phase, MaaS Enablers pursue institutional reforms to enable MaaS innovation activities, and fund experimentations. An example here is the national government in Denmark. In 2018, it adopted a new act of legislation that, among other things, states that public transport data and tickets should be made available to external MaaS Operators (Hedegaard Sørensen et al., 2020).

To support the diffusion of MaaS, MaaS Enablers promote the diffusion of mobility services and/or the use of harmonized digital interfaces for data and ticketing. This is to increase the number of potential mobility services to integrate into MaaS, as well as the group of potential users. TfNSW has acted on the latter by developing a digital payment infrastructure that other mobility service providers are free to adopt (cf. the market-driven scenario in Figure 7). In the use phase, MaaS Enablers enable external actors to take on the MaaS Integrator and MaaS Operator roles. HSL's and PTA-VG's generic contracts for external MaaS Operators are two examples of preparing for taking a MaaS Enabler role in the use phase.

Finally, the *Laissez-Faire* role can be understood as a wait-and-see approach, which entails collecting evidence and monitoring MaaS developments, but otherwise continuing business as usual[7]. Although this approach is passive, it is in many cases a deliberate choice: to *step away* to give external actors leeway for innovation. For example, this was the approach that TfNSW initially adopted when ride-sourcing services entered New South Wales, prior to introducing legislation that made these businesses lawful. Similarly, the national government in Sweden has arguably adopted this stance in relation

to MaaS. Some researches have noted that it can be justifiable for public sector actors to initially adopt Laissez-fair roles when dealing with uncertain endeavors, such as MaaS developments, since it may help them avoid using tax money recklessly (Wallsten et al., 2020). In contrast, others have concluded that public sector actors (especially PTAs and other public sector controlled mobility service providers) must shift away from Laissez-Faire roles to pave the way for MaaS developments (Audouin & Finger, 2019).

The empirical studies demonstrated that MaaS governance roles vary across different public sector actors (and sometimes between organizational units). For instance, LVM and the City of Helsinki have been prone to open and push for a market-driven scenario (i.e. taking MaaS Enabler roles), while HSL has questioned this approach. Similar disagreements have been observed between the Swedish Innovation Agency and PTA-VG in Sweden, where the former has repeatedly criticized the latter for not opening its sales interface (quick enough) for external MaaS Operators. Furthermore, PTA-VG's changing approach to MaaS governance (across Studies 1, 3 and 5) illustrated how MaaS governance approaches can vary over time. Consequently, it is not easy to assess what governance approach will prevail in the studied contexts.

Nonetheless, as of spring 2020, the public sector strategies in Sweden and Finland point towards a governance pathway in which public sector actors are involved as MaaS Promoters, MaaS Partners, and MaaS Enablers in the development phase, as MaaS Partners and MaaS Enablers in the diffusion phase, and as MaaS Enablers in the use phase. In other words, the current public sector involvement is profoundly hands-on and hands-off in the early MaaS developments in both countries but seems to become increasingly less hands-on and more hands-off as MaaS developments progress to later phases. This is notwithstanding Finnish MaaS developments being more underpinned by market-oriented logics than their Swedish counterparts, as well as despite the fact that initial governance actions in Sweden pointed towards a different governance pathway.

In contrast to Swedish and Finnish MaaS developments, public strategies in other countries are currently pointing towards governance pathways in which the public sector involvement in the use system is hands-on. For example, the PTA in the Oslo and Aakershus region in Norway (Ruter) is investigating if it can adopt the MaaS Operator role and, as previously mentioned, BVG operates a MaaS service in Berlin.

In New South Wales, the governance pathway is thus far unclear, although TfNSW has been significantly hands-on involved thus far. Furthermore, it should (once again) be noted that MaaS developments are nascent (across the empirical studies and in general) and that the aforementioned developments are only indications. More time must pass before it is known how operational tasks will become distributed across the public and private sectors in the diffusion and use phases. Governance pathways will most probably diverge across countries and regions, and a mixed model seems probable in many places, i.e. that publicly and privately managed MaaS services coexist and compete.

8.3 Summary

The thesis recommends fifteen activities for public sector actors that want to facilitate MaaS developments. These activities can be summed up in three overarching principles. Firstly, set an inspirational long-term vision for MaaS in collaboration with private and social sector actors. The vision should build on transport policy objectives and link with other policy sectors. Secondly, develop an agenda for MaaS developments that coordinates tactical and operational activities. The agenda should build on inter-organizational collaboration, possibly including a diverse group of users. In addition to activities directly related to the MaaS concept, the agenda should encompass activities that strengthen mobility service and active mobility regimes (and the structural links between them), and which weaken the private car regime. Thirdly, facilitate MaaS experimentation and joint knowledge generation by investing in pilots and operations, and by establishing internal institutional conditions that favor learning and risk taking.

The thesis also develops a framework for MaaS governance pathways, which recognizes that public sector governance activities are vital for MaaS developments regardless of the public sector actors' intended operational roles in the emerging MaaS value chains. The framework identifies three active governance roles that public sector actors (that wish to facilitate MaaS developments) can adopt depending on whether they prefer to be hands-on and/or hands-off involved in MaaS developments: MaaS Promoter, MaaS Partner, and MaaS Enabler. Additionally, public sector actors can adopt a passive Laissez-Faire role by not undertaking any governance responsibilities beyond monitoring activities.

1. This reluctance is perhaps related to the *not invented here* syndrome (cf. Antons & Piller, 2015).
2. Likewise, PTA-VG struggled with understanding external actors' plans. Generally, the planning and communication cultures of PTA-VG and of (many of) the start-up firms that it collaborated with on MaaS developments were mismatched.
3. Yet, the involvement of users does not ensure better innovation outcomes (Clausen & Fichter, 2019).
4. For instance, the needs of young and old people have thus far received little attention by MaaS practitioners and scholars (Casado et al., 2020; Mulley et al., 2020).
5. Cf. Engeström, 1987 for a useful hierarchy of different types of learning.
6. An actor can be described as playing a role, or a web of roles, based on its core activities and attitudes in relation to the governance task (Wittmayer et al., 2017).
7. A public sector actor can also actively choose to impede MaaS developments. The framework does not cover this possibility.

CHAPTER 9
Reflections

This chapter concludes the thesis by reflecting on the research approach and the knowledge contribution in relation to the overall aims. Avenues for future research are suggested thereafter, and some concluding remarks are offered.

9.1 Research Approach

One of the most distinctive aspects of the research methodology is the participatory element in the three empirical studies situated in Sweden. In addition to providing unique access to knowledge and thus opportunities to develop a deep understanding of Swedish MaaS developments, the participatory approach also entailed an ambiguous dual role as both researcher and policy-practitioner. As mentioned in Chapter 4 (and discussed at length in Smith (2017)), this dual role carried risks in relation to misuse of information, research consent, representative sampling, and researcher subjectivity. An explicit strategy for risk mitigation was therefore warranted, which aimed at remaining mindful of and transparent regarding the dual role during all phases of the research process.

The involvement in the studied system is not an unusual position within either collaborative innovation or sustainability transitions research. The sustainability transitions research community has an outspoken ambition to achieve practical impact on policymaking, and is thus active within both academic and policy-practice arenas (Rotmans, 2005). Accordingly, how sustainability transitions researchers should engage in and interact with initiatives within the ongoing transition processes they study have been widely discussed topics (cf. Köhler et al., 2019). Wittmayer and Schäpke (2014) proposed that sustainability transitions researchers should "create spaces for societal learning by, inter alia, giving space to participants, fostering mutual learning about sustainability challenges and possible solutions, and being critical of power relations and implicit ideologies" (p. 494).

Wittmayer and Schäpke (2014) also identified five participatory roles that researchers can adopt, all of which have been present in this doctoral research project. Through the public servant position at PTA-VG, the author of the thesis has participated in policy formulation (cf. change agent), facilitated experimentations (cf. process facilitator), mediated different perspectives (cf. knowledge broker), analyzed outcomes (cf. reflective scientist), and reflected upon his own position and power (cf. self-reflexive scientist). Hence, the methodology approach can be described as process-oriented, which implies that the researcher's knowledge is one of many sources that have influenced the studied system as well as the research findings (cf. Miller, 2013). Thus, the produced knowledge about MaaS developments might not be as salient, credible, and legitimate as if produced through a more distant approach, but may present more achievable pathways towards facilitating the development, diffusion, and use of MaaS services that, in the long term, contribute to improving the sustainability of personal mobility systems (cf. ibid.).

The produced knowledge is moreover concerned with perceptions of truths rather than with objective truths. For instance, the involved actors' perceptions of how regulations influence their action spaces were seen as more relevant than their actual action spaces, since what is perceived and considered is what will constrain the range of activities the most (cf. Strömberg, 2015). Accordingly, qualitative data collection and analysis techniques were deemed as appropriate for the research aims. Still, the respondents mentioned a pressing need for empirical evidence on the effects of MaaS. This calls for more quantitative and aggregate research designs (see Section 9.3).

9.2 Contribution to Mobility-as-a-Service Practice

This thesis reports an in-depth cross-study analysis of five empirical studies of MaaS developments in Sweden, Finland, and Australia. While the contributions of the individual studies are discussed in the appended papers[1], this section proposes main contributions in relation to the primary aim of devising a better understanding of how public sector actors can facilitate action in the early phases of MaaS development while also ensuring that MaaS supports a transition towards more sustainable personal mobility systems.

The reported findings foster a better understanding of MaaS developments and MaaS governance in three ways. Firstly, the analysis of expectations of MaaS finds that the level of uncertainty is high but illustrates that actors involved in MaaS developments nonetheless have strong and contradicting ideas about how MaaS will influence personal mobility systems (Chapter 5). This calls for a greater focus on generating and sharing empirical evidence on the effects of MaaS going forward (cf. Karlsson et al., 2017). Secondly, the classification of institutional factors demonstrates that MaaS developments, despite being pushed forward by major societal trends, are hampered by multiple formal and informal barriers at several different societal levels (Chapter 6). This suggests that MaaS developments are more complicated, and require more types of innovation, compared to what has usually been recognized (e.g. Li & Voege, 2017). It also shows

that MaaS developments are intertwined with the diffusion of mobility services, and with the decline of the private car regime, thus questioning the usefulness of stand-alone MaaS initiatives and roadmaps. Thirdly, the review of public sector activities illustrates that a range of public sector actors are pursuing several types of governance activities that directly or indirectly as well as consciously or unconsciously shape MaaS developments (Chapter 7). This challenges the popular view of public sector actors in general, and PTAs in particular, as largely passive and reluctant in relation to MaaS (cf. Audouin & Finger, 2018; 2019)

Drawing on these findings, the thesis outlines MaaS governance principles for public sector actors that want to push and steer MaaS developments, and develops a framework that describes public sector governance pathways (Chapter 8). While the principles can guide the drafting of (more) effective MaaS governance strategies, the framework can hopefully assist dialogues about methods of intervention. The framework illustrates that the public sector involvement can be hands-on in the early phases of MaaS developments even when the intention is that the private sector should adopt the new operational roles in the value chain (MaaS Operator and MaaS Integrator). Hence, it offers a (more) comprehensive understanding of the public-private dynamic in MaaS developments, which has been a much-debated topic thus far (e.g. Holmberg et al., 2016; POLIS, 2017; UITP, 2016).

In addition to the abovementioned contributions, this thesis also provides knowledge developments that enhance the conceptual clarity of MaaS. The thesis proposes a value-free definition of MaaS (Chapter 1), classifies the central roles in emerging value chains for MaaS (Chapter 2), and conceptualizes MaaS developments as an innovation process that requires inter-organizational collaboration and which might transform personal mobility systems to more polycentric configurations (Chapter 3). These knowledge developments can hopefully help mitigate the current confusion of what MaaS is and what it is not (cf. Hensher et al., 2020) and facilitate (better) discussions about MaaS developments, and MaaS governance.

9.3 Contribution to Sustainability Transitions Studies

The reported research has been problem driven. Theoretical constructs were applied to organize and make sense of the analysis of MaaS developments; less focus was placed on how the performed analysis could refine the applied theories. Yet, tackling practical problems has been recognized as an apt way of advancing theory (Stern, 2014). In particular, unorthodox case studies provide ample opportunities for falsifying or verifying existing theory (Flyvbjerg, 2006; Ruddin, 2006).

The undertaken research stands out from the bulk of sustainability transition studies for two main reasons. Firstly, the motivation behind, and impact of, public sector activities were focal points of enquiry in this thesis. This is unusual, as despite recognizing that the public sector is imperative for sustainability transitions (e.g. Rip & Kemp, 1998),

the behavior of public sector actors remains understudied (Johnstone & Newell, 2018; Patterson et al., 2017). Secondly, the thesis adopted a broad understanding of innovation, recognizing different types of innovation and emphasizing that innovation encompasses the complete journey from initial idea to societal impact (cf. Lyons et al., 2012). MaaS developments' central mechanism for generating long-term sustainability gains was moreover conceptualized as to strengthen service regime alignments within personal mobility systems (cf. van Welie et al., 2018), in contrast with the more conventional focus on replacing core technologies that are considered unsustainable. Although a diversification has been observed in recent years (Köhler et al., 2019), the literature on sustainability transitions is still dominated by empirical cases of technological-centered innovation, such as the introduction of solar power (e.g. Gosens et al., 2020), aviation biofuels (e.g. Mousavi & Bossink, 2020), and off-shore wind farms (e.g. van der Loos et al., 2020). Due to these distinct characteristics[2], the undertaken research in this thesis opened opportunities to test some of the bedrock assumptions within sustainability transitions studies. In particular, the thesis' findings advocate for refined conceptualizations of the nature and roles of the public sector (cf. Johnstone & Newell, 2018).

Due to the broader ideological context in the Netherlands in the mid-1990s in which sustainability transitions studies emerged, the fundamental concepts are underpinned by ideas of the hollowing out and retreat of the state (Johnstone & Newell, 2018). Accordingly, in much of the literature, the prescribed role of the public sector has (only) been twofold: to put pressure on the existing regime through economic instruments and regulations, and to nurture and protect private sector niche-innovation by mobilizing actors and by creating boundary conditions within which the transition process can operate (Geels & Kemp, 2012). According to the Transition Management Framework, to accomplish these two tasks, the government should initially act as a director and catalyst and then gradually transform into a controller and consolidator as the transition process progresses (Rotmans et al., 2001). An implicit but major assumption here is that although the public sector has important roles to play in sustainability transitions, it is essentially the private sector that innovates.

This thesis defies this narrow view of public sector intervention by illustrating that the public sector can play important hands-off and/or hands-on roles in the emerging use system as well as in the systems for development and diffusion of MaaS (see Table 4). This does not only imply that the public sector can actively create and shape markets (cf. Mazzucato, 2016), but also that public sector actors can perform operational innovation tasks. Overall, the observed front-seat role of some of the studied PTAs challenges the assumption that radical innovation primarily takes place in niches. Rather, the findings provide empirical backing to the claim that regime actors have complementary assets that are crucial in the development phase as well as the diffusion and use phases (cf. Teece, 1986). Accordingly, this thesis questions the effectiveness of small and exclusive transition arenas, as advocated by the transition management literature (e.g. Loorbach, 2007; 2010). In contrast, the studied MaaS developments illustrate that the involvement of both public

and private incumbents from traditionally separated regimes can be important for the operationalization of transition visions. This indicates that transition arenas should be problem driven (cf. Zijlstra & Avelino, 2012), and (within practical limits) involve as many of the actors that either would be significantly affected by the proposed transition or whose competences and resources are deemed essential for driving the transition forward. Since these actor constellations are likely to be diverse, boundary-spanning actors that can mediate between different viewpoints have central roles to play (cf. Torfing, 2016).

While some of the identified public sector activities outlined in this thesis were proactively and intentionally meant to facilitate MaaS developments, others, which were perceived to influence MaaS by the respondents (positively and otherwise), were either broader in character or unintentionally linked to MaaS. It was also evident that the public sector approaches were neither stable nor coherent. Rather, the observed public sectors comprised multiple actors with distinct agencies and agendas, which at different points overlapped, complemented each other, or competed. The underpinning motives for and prioritization of MaaS developments varied across the public sector actors and seemed to be influenced by political motives as well as power relations within and beyond the public sector. These findings are in conflict with the conceptualization of the public sector as a uniform group of neutral and rational actors (cf. Johnstone & Newell, 2018). Consequently, this thesis calls for more nuanced, relational, and multi-dimensional understandings of public sector roles in sustainability transitions. Beyond recognizing that the dominant method of intervention can vary across situations and between transition phases, this also entails appreciating that the public sector is not suspended in mid-air (as argued by Marx and Engels, see Miliband, 1989) but rather influenced by the private sector and by public opinion (cf. Geels et al., 2012), the sustainability transition in focus is only one of many competing topics on the public sector agenda (cf. Osborne, 2006), and the public sector consists of a multitude of inter-reliant actors that can influence sustainability transitions intentionally and/or unintentionally (cf. Johnstone & Newell, 2018).

The thesis also provides further empirical backing to the proposition that public sector actors are often disproportionately focused on nurturing innovation (e.g. Geels & Kemp, 2012). In the empirical studies, MaaS developments were hindered by the hegemonic position of the private car. Still, the observed MaaS-related policy packages rarely included car-restricting policies. To create space for niches to develop, public sector actors must take more active roles in facilitating the decline and phasing out of prevalent regimes (e.g. Parkhurst et al., 2012; Zijlstra & Avelino, 2012), and prescriptive tools such as the Transition Management Framework should be amended to put greater emphasis on this. Here, it has been proposed that it is a good strategy to first help niche innovations develop and expand prior to putting pressure on the prevalent regime to delegitimize the claim that radical change is not possible (Geels et al., 2012). The findings presented in this thesis indicate that it may be a better approach to nurture niche-innovations and put pressure on the regime simultaneously, since this can create mutually reinforcing and legitimizing relationships between niche growth and regime decline.

9.4 Avenues for Future Research

Based on the perceived pressure from societal changes such as digitalization and the rise of the sharing economy, the respondents often presumed that the diffusion of MaaS is an inevitable development. The recent success of intermediary platforms and meta search engines in other sectors was used as evidence that MaaS has a principal place within future personal mobility systems. Thus, MaaS seems to be en route to becoming post-political (cf. Hopkins & Schwanen, 2018) in the sense that the question asked is how public sector actors can best shape the development, diffusion, and use of MaaS, rather than if public sector actors should facilitate MaaS developments at all (so also in this thesis). Still, as long as MaaS includes publicly funded assets and services, its introduction is neither neutral nor obvious. On the contrary, it is a political and complex question that concerns the distribution of resources to different groups in society (Isaksson et al., 2019).

The recentness of the MaaS concept made empirical analyses of the long-term effects of MaaS developments infeasible within the scope of the reported doctoral research project. However, as MaaS developments progress, future MaaS research should critically examine fundamental questions, such as what societal effects do (the diffusion and use of) different types of MaaS services produce, and for what policy objectives and under what circumstances are public sector investments in MaaS developments viable and equitable? Indeed, despite "the persuasive rhetoric around MaaS that makes grand promises about efficiency, choice and freedom" (Pangbourne et al., 2020, p. 35), the empirical evidence on what types of users MaaS can attract and what potential MaaS has to influence user satisfaction, transport exclusion, travel behavior, or some other parameter, is very limited (Karlsson et al., 2017). Hence, more empirical evidence is needed. This demands structurally evaluated long-term and diverse MaaS operations in various contexts (Hensher et al., 2020). Here, inspiration can be found in Sweden and in the Netherlands where standard evaluation approaches for MaaS operations are under development (see I&W, 2018; Karlsson et al., 2019). However, to verify the societal value of MaaS, a plurality of conceptual and empirical research as well as cross-fertilization across research traditions will be needed. For instance, scenario-based simulations based on (qualitative and quantitative) real-world observations of MaaS users' mode choice behavior could be used to predict the impacts of MaaS diffusion on personal mobility systems (cf. Becker et al., 2020).

Beyond highlighting a need of returning to the basics, this thesis also reveals more specific research needs. The analysis of actor expectations illuminated that MaaS is thought to support active mobility, but that there is a lack of explicit strategies in this space. This calls for research on how MaaS services can be designed to promote active mobility. Moreover, MaaS is envisioned to challenge the practice of planning personal mobility around distinct mobility modes (cf. Docherty et al., 2018). Hence, studies that address how policy interventions can facilitate the decline of mode silo planning practices

are needed. The analysis of institutional factors identified many barriers to MaaS developments, with the most discussed barriers being the fierce competition from the private car regime, the lack of viable business models for MaaS, how to *share* customers, and the difficulty in designing MaaS experiments so that involved actors can leverage its outcomes. Accordingly, investigations of how to address these issues can be valuable for future MaaS strategies. The analysis of public sector activities showed that collaborative activities are praised as effective by the invited actors but contested by the actors that were left out. This brings into question what types of actors should be summoned to collaborate on MaaS developments so as to improve innovation performance and to ensure equitable outcomes. Who decides the trajectories of sustainability transitions, on what authority and on whose behalf; these are in general fundamental yet largely underexplored questions (e.g. Gillard et al., 2016; Shove & Walker, 2007).

More research is also needed to establish the transferability of the findings. This thesis is predominantly based on empirical studies of MaaS developments in Sweden and Finland. This Nordic socio-political context is arguably quite distinct, for instance in terms of comprehensive welfare states and large proportions of the populations being employed by the public sector (cf. Hilson, 2008). The analysis is moreover deeply colored by sustainability transition studies and collaborative innovation concepts. Both these literatures have in large part emerged in Western Europe (at least the concepts applied in this thesis). Hence, to establish the transferability of the findings to other socio-political contexts, they must be tested, validated, and refined through empirical studies in other countries, and preferably through analyses that deploy other public administration theories. Furthermore, the findings rest on a small and distinctive sample of cases. The empirical studies all represent the initial phases of MaaS developments and are among the first of their types. Studies of other cases of MaaS developments would therefore be valuable, e.g. differently organized MaaS developments, more advanced MaaS developments, and MaaS developments that are more representative of the entire population.

Finally, more work remains to turn the produced knowledge into readily applicable tools. In particular, the developed governance principles and pathways treat the public sector as one cohesive unit, although the empirical studies illustrate that the public sector comprises a multitude of actors with individual agencies. Public sectors are moreover organized differently across jurisdictions. Hence, the proposed MaaS governance principles and pathways must be broken down, adapted, and concretized to better give advice to specific public sector actors in specific situations. The principles moreover leave many questions unanswered. For instance, how can MaaS strategies be aligned with spatial planning, what types of models and tools for inter-sectorial collaboration can improve inter-organizational trust and understanding in MaaS collaborations, how can PTAs organize to work (more) systematically with MaaS experimentation, and how can potential MaaS users (and non-users) become co-creators of MaaS developments? These, and other related questions, should be investigated further.

9.5 Concluding Remarks

The Transition Management Framework contains a process dimension, which describes a non-sequential but cyclical process of iterations between theoretical reflection and practical experiments (see Loorbach, 2010). In short, transition experiments should be monitored, and adjustments should be made to visions and agendas based on the generated insights (Loorbach, 2007; Voß et al., 2009). In the MaaS universe, the 2013-14 UbiGo pilot in Gothenburg represented the first MaaS experiment that was thoroughly documented, evaluated, and disseminated to a wider audience. Drawing on the Transition Management Framework, this can be interpreted as the first cycle of MaaS developments since the pilot's promising outcome sparked MaaS developments in both Sweden and elsewhere. A lot of water has flowed under the bridge since then, but still, most MaaS developments thus far have taken place at the strategic and tactical levels. MaaS pilots have (actually) been quite few, and the shortage of empirical evidence on the effects of MaaS has been striking.

However, this seems to finally be changing now. Within the last year, several MaaS pilots and implementations have been launched (e.g. Jelbi in Berlin and Trafi in Stockholm) and many more are planning to launch shortly (e.g. MVG in Munich and LIMA in Gothenburg). Moreover, researchers are gathering empirical evidence from at least some of these (e.g. Amaze in Amsterdam and Tripi in Sydney). Consequently, it looks as though the second cycle of MaaS developments may be coming to a close soon. In other words, in the not so distant future, public sector actors might have much better opportunities to develop (or revise) MaaS strategies that pave the way for equitable MaaS developments that tackle (some of) the transport sector's pressing sustainability problems. The author's hope is that the findings presented in this thesis can assist and accelerate these processes.

1. The intended benefactor of this knowledge is first and foremost the community of researchers, policymakers, and practitioners concerned with MaaS developments. It was assumed that this community primarily attends transport conferences and reads transport journals. The bulk of the research output has therefore been presented at transport-themed conferences and published in international transport journals.
2. In addition to broad interpretations of innovation and sustainability transitions, the understanding of governance in this thesis is arguably inclusive too (cf. steering and rowing in Peters, 2011).

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